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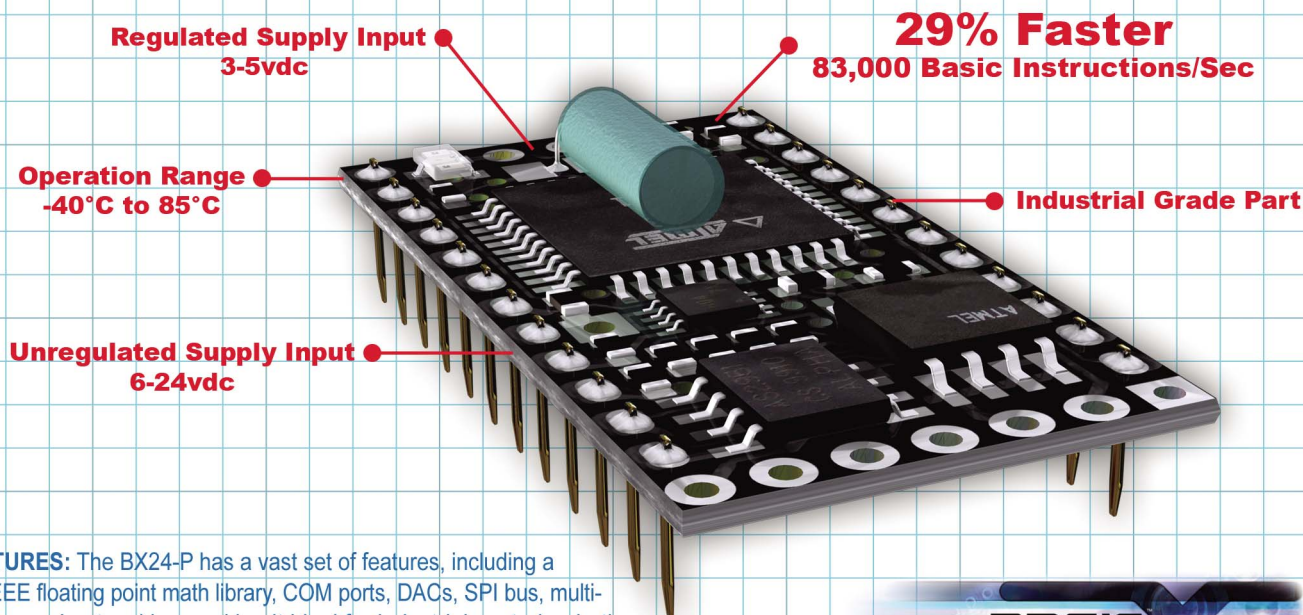
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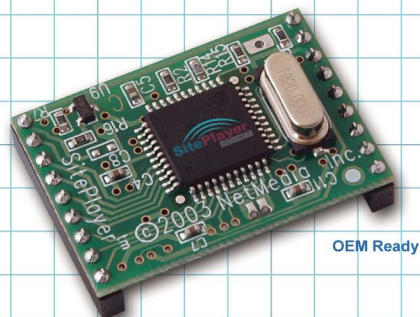
FEATURES: The BX24-P has a vast set of features, including a full IEEE floating point math library, COM ports, DACs, SPI bus, multi-tasking and networking, making it ideal for industrial control, robotics, automated testing equipment and home automation. BX24-P is able to monitor and control all your switches, timers, motors, sensors, relays, and more. Measuring just 1.25" X .75", OEMs can easily see the value of this little powerhouse.



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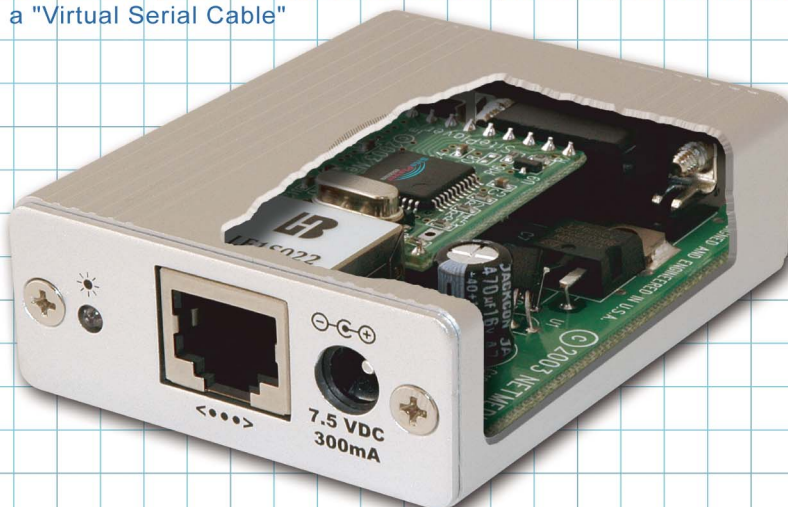


Features - 10BaseT, ARP, UDP, TCP/IP, DHCP, Link Local, Bonjour, ICMP Ping, HTTP, Telnet, Daytime protocol, Discard protocol, 4 IP addresses, Serial AT command mode for external processor control of Ethernet sessions.

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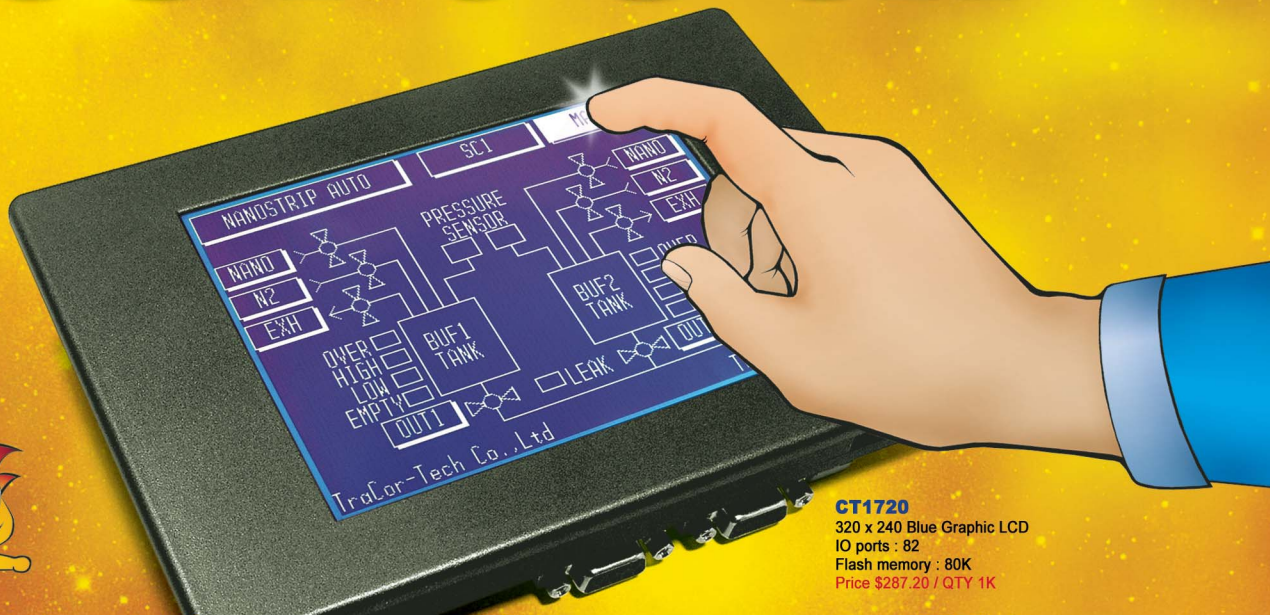


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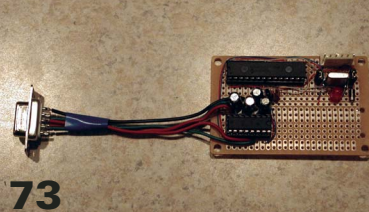


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NUTS AND VOLTS

JUNE 2006

PROJECTS and FEATURES

- 34 CONTROL YOUR WORLD**
Interface your PC to a portable digital multi-meter.
■ *By Michael Simpson*
- 38 PANORAMA MANIA**
Cure "bad stitching" with this digital camera panorama shooting platform that uses a modified IR remote.
■ *By J. Ronald Eyton*
- 54 ELECTRICALLY CONDUCTING POLYMERS**
While plastics have a variety of useful properties, electrical conduction was not counted as one of them ... until 1986.
■ *By Faiz Rahman*
- 58 PROGRAMMING THE POCKET PC**
Get a brief intro to the free "eMbedded Visual Tools SDK."
■ *By Walter O. Krawec*
- 67 SPACECRAFT FILMS REOPENS THE NEW FRONTIER**
This set of six DVDs documents the pioneering efforts that took us into space.
■ *By Edward B. Driscoll, Jr.*
- 73 USB DEVICE CONTROL**
Simple ways to control devices through USB have become essential.
■ *By Alexander Enzmann*

ON THE COVER ...

- 44 "MAIL DELIVERED" DETECTOR**
Save yourself unnecessary trips to the mailbox with this handy gadget.
■ *By Charles Irwin*



COLUMNS

- 08 TECHKNOWLEDGEY 2006**
Events, advances, and news from the electronics world.
- 14 STAMP APPLICATIONS**
Spin, baby, spin.
- 18 PERSONAL ROBOTICS**
Zen and the art of Zigbee: Part 3.
- 22 Q&A**
Negative resistance demystified and lots of cool car gadgets.
- 79 OPEN COMMUNICATION**
TV on a cell phone.
- 82 GETTING STARTED WITH PICs**
Using the PIC external interrupt.
- 88 THE DESIGN CYCLE**
Easy ARM hardware.

DEPARTMENTS

- 06 READER FEEDBACK**
- 30 NEW PRODUCTS**
- 52 SHOWCASE**
- 53 NEWS BYTES**
- 66 ELECTRO-NET**
- 96 CLASSIFIEDS**
- 100 NV BOOKSTORE**
- 102 TECH FORUM**
- 105 ADVERTISERS INDEX**

Nuts & Volts (ISSN 1528-9885/CDN Pub Agree#40702530) is published monthly for \$24.95 per year by T & L Publications, Inc., 430 Princland Court, Corona, CA 92879. PERIODICALS POSTAGE PAID AT CORONA, CA AND AT ADDITIONAL MAILING OFFICES. POSTMASTER: Send address changes to **Nuts & Volts, P.O. Box 15277, North Hollywood, CA 91615** or Station A, P.O. Box 54, Windsor ON N9A 6J5; cpcreturns@nutsvolts.com



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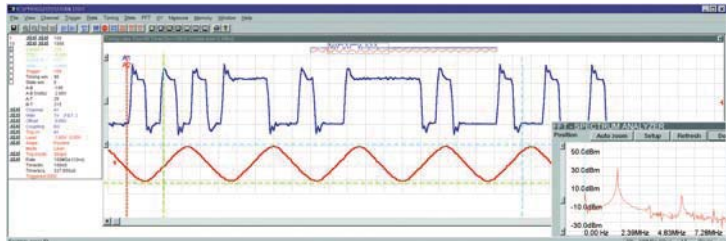
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EMI ... OH MY!

While International Rectifier is an experienced and venerable company, it looks like their latest press release on their LS series radiation hardened power converters needs a bit more editing. They tout "Built-In EMI"! Well, who wants that?! Maybe "Built-In EMI Suppression" would have made more sense. BTW, their claimed compliance with MIL-STD-461C is odd, since that version has been obsolete for about 13 years.

Ed Price
San Diego, CA

Writer Response:

I went back to my original file and checked it out. The version I submitted has the term EMI in it only twice — once in the photo caption and once in the body. In both cases, it is followed by the word "filter." I wouldn't worry

too much about it, though — anyone who knows what EMI is knows it to be undesirable and would read it either as a typo or just shorthand for "EMI protection." I thought the most amazing thing about the device is the price.

My recollection is that some government contracts call for equipment to be compliant with earlier versions of MIL-STD-461. This could be because it's an old contract that was never updated or because a particular application doesn't need to meet the most modern specs. The latest version I have on hand is 461D, from back in 1993. I think we're up to 461E now, but I don't do much in the EMC area anymore, so I never picked up the new one. It's not exactly coffee table material. But for whatever reason, the IR press release does say 461C.

Jeff Eckert
Techknowledgey 2006

A HAPPY HOBBYIST

I wished I started with my sub-
Continued on page 99

by J. Shuman

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P.O. Box 15277
North Hollywood, CA 91615

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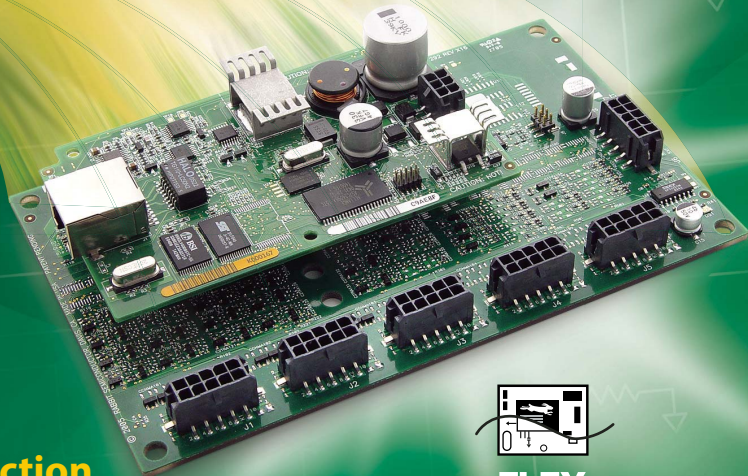
Debbie Stauffacher

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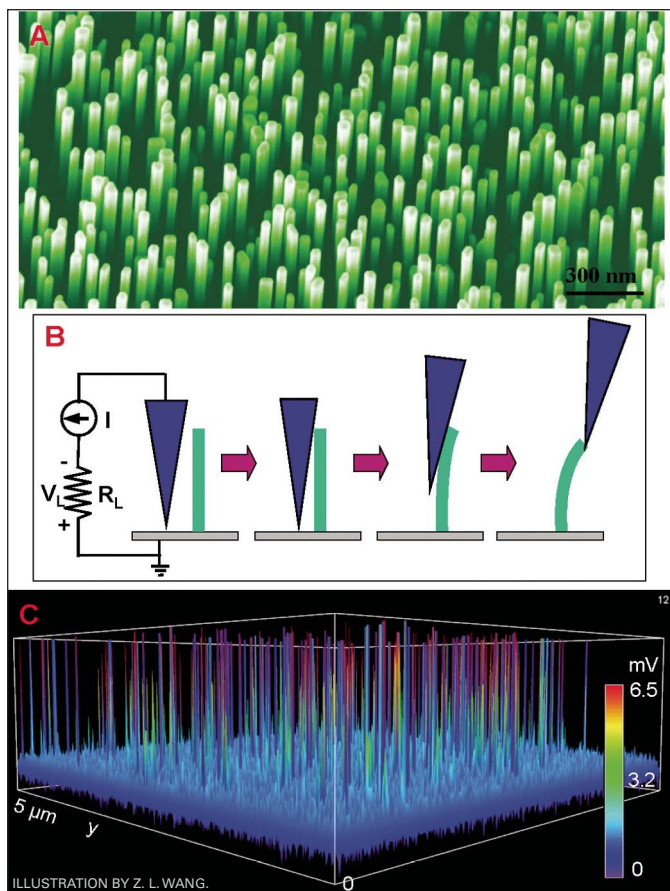


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Solutions That Work

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

NANOGENERATORS TURN MOTION INTO ELECTRICITY



■ Tiny nanowires create electricity that may power implantable medical and other devices.

Researchers at the Georgia Institute of Technology (www.gatech.edu) have come up with some tiny nanowires that generate electricity when they vibrate. Just like the quartz crystal in a watch, the zinc-oxide nanowires are piezoelectric, so bending causes them to produce an electrical charge. Only 20 to 40 billionths of a meter in diameter, each fiber works with millions of others to form a nanogenerator capable of producing significant amounts of

energy from the slightest activity.

To study the effect, the researchers grew arrays of zinc-oxide nanowires, then used an atomic-force microscope tip to deflect individual wires. According to Zhong Lin Wang, a regents professor in the School of Materials Science and Engineering, as a wire was contacted and deflected by the tip, stretching on one side of the structure and compression on the other side created a charge separation — positive on the stretched side and negative on the compressed side — due to the piezoelectric effect. The charges were preserved in the nanowire because a Schottky barrier

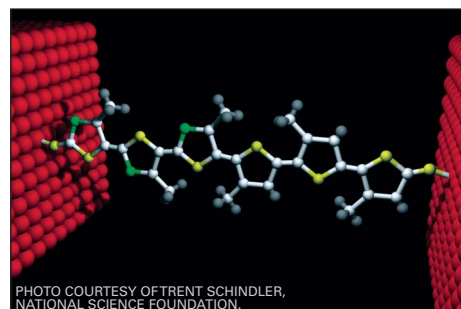
was formed between the AFM tip and the nanowire. The coupling between semiconducting and piezoelectric properties resulted in the charging and discharging process when the tip scanned across the nanowire.

The top portion of the illustration shows an array of the nanowires, and the middle image depicts a schematic of how an AFM tip was used to bend them to produce current. The bottom image depicts output voltages produced by the array.

According to the researchers, motions from body movement, the stretching of muscles, and even the

flow of liquids should be able to generate electrical charges in the wires, making them useful for implantable medical devices, sensors, portable electronics, and a variety of other applications.

SINGLE-MOLECULE DIODE COULD REVOLUTIONIZE ELECTRONICS



■ This single-molecule diode could eventually replace conventional devices and allow electronic devices to be shrunk to very tiny sizes.

Using the power of modern computing and some innovative theoretical tools, an international team of researchers has come up with a single-molecule diode and figured out how it works. Created by a research team at the University of Chicago (www.uchicago.edu), the diode is merely a few tens of atoms in size and 1,000 times smaller than its conventional counterparts. Recently, theorists from the University of South Florida (www.usf.edu) and the Russian Academy of Sciences (visit www.intertec.co.at/itc2/partners/RA_S/Default.htm for English-language information) have explained the principles that make the device work.

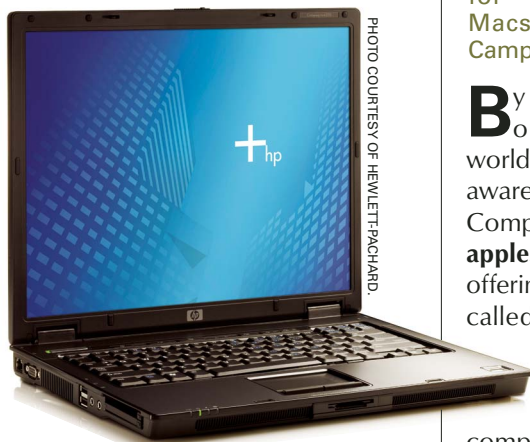
The researchers showed that electron energy levels in a molecule are efficient channels for transferring electrons from one electrode to another. Because the molecule in the diode is

asymmetrical, the electronic response is also asymmetrical when voltage is applied. The asymmetry contributes to a phenomenon called "molecular rectification" in which the channels conduct electrons in one direction but limit flow in the opposite direction when the voltage polarity reverses.

That property makes the molecular diode a potential gatekeeper for circuits and a candidate to one day replace silicon in computer chips. Because diodes are critical components within computers, audio equipment, and countless other electronic devices, using these tiny devices in place of existing ones, many products could be shrunk to incredibly small sizes.

COMPUTERS AND NETWORKING

CINGULAR AND HP TEAM UP



■ HP business notebooks will soon be available with built-in global 3G capabilities.

In a joint statement, Hewlett-Packard (www.hp.com) and Cingular Wireless (www.cingular.com) announced a marketing agreement that will integrate Cingular's BroadbandConnect technology into HP business notebook computers later this year. Customers will be afforded wireless access to email, the Internet, and business data both in the United States (either with BroadbandConnect or high-speed EDGE services) and in more than 100 other countries worldwide in which there are UMTS or GPRS/EDGE net-

works. BroadbandConnect service is expected to be available in most major US markets by the end of this year. According to the announcement, UMTS/HSDPA is the global standard and natural 3G evolutionary path for GSM providers, with 45 countries currently offering UMTS service. It provides average download speeds between 400 to 700 kbps, with bursts to more than 1 Mbps.

Cingular's UMTS/HSDPA-based BroadbandConnect service is available in 16 markets covering 52 cities and is expected to be available in most major markets by the end of this year. The company's EDGE network, with coverage in 13,000 cities and towns, provides average download speeds of up to 135 kbps.

MORE VERSATILITY FOR INTEL MACS

■ Parallels Workstation 2.1 software for Intel-based Macs goes Boot Camp one better.

By now, everyone in the world is probably aware that Apple Computer (www.apple.com) is now offering a program called Boot Camp that allows owners of the new Intel-based Macintoshes to run Windows XP. However, one complaint has been that you can't run both systems at the same time and must reboot to switch from one to the other.

However, Parallels, Inc. (www.parallels.com), has introduced Workstation 2.1, which not only eliminates that annoyance but also allows users to run Windows of any variety, Linux, or practically any other operating system simultaneously. The product takes advantage of Apple's inclusion of Intel Core Duo architecture chips into the new Mac models.

Because the Intel Core Duo chipset is x86-compatible, the Parallels "virtualization engine" can virtualize the hardware, thus enabling Mac users to build virtual machines running nearly any

x86-compatible OS, including Windows 3.1-XP/2003, Linux, FreeBSD, Solaris, OS/2, eComStation, and MS-DOS.

As of this writing, the product is still in beta stage and can be downloaded on a trial basis. However, the final release, which should be available by the time you read this, will go for \$49.95.

BYE-BYE TO WINDOWS 98

It has been noted on the Microsoft website (www.microsoft.com) that the company will no longer support Windows 98 or Windows Millennium Edition as of July 11, including security updates and paid incident support. However, online self-help support may be extended beyond that deadline. The products are said to be outdated and security risks to users, and it is recommended that users upgrade to a newer OS, such as XP, as soon as possible.

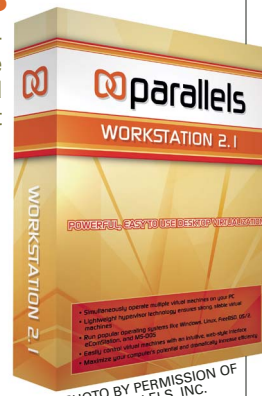
CIRCUITS AND DEVICES

SAT PHONES GETTING (a Little) CHEAPER

If you are planning to do some traveling to remote places, or if you simply live in such a place, you might find that a standard cell phone doesn't do you a lot of good. If you have some extra bucks to spend, however, you can consider a satellite phone instead.

Rather than depending on an Earth-bound cell network, sat phones receive signals directly from orbiting satellites. The Iridium system (www.iridium.com), for example, uses a system of 66 low-Earth orbiting, cross-linked satellites and is said to cover the entire globe, including oceans, airways, and polar regions. Another provider is Globalstar (www.globalstar.com), which is better suited to US and Caribbean usage. Note, however, that sat phones do not work inside a building or underground — you must be able to see the sky to make a connection. But you can use them to get email and surf the web.

A Qualcomm GSP-1600 sat



INDUSTRY AND THE PROFESSION

STANDARD ADDRESSES ENVIRONMENTAL ISSUES WITH COMPUTERS

Assessing the environmental impact of computer systems before they are purchased has long been a challenge for those who buy computer equipment for companies, government agencies, and other organizations. A standard from the IEEE (www.ieee.org), which was initiated by and developed with support from the US Environmental Protection Agency (EPA; www.epa.gov), has been created to help resolve this issue. The standard, IEEE 1680™, "Standard for Environmental Assessment of Personal Computer Products," will help purchasers reduce the environ-

mental impact of the computers they buy, use, and discard.

According to the Institute, IEEE 1680 is the first US standard to supply environmental guidelines for institutional purchasing decisions involving desktop and laptop computers and monitors. It offers criteria in eight categories: materials selection, environmentally sensitive materials, design for end of life, end-of-life management, energy conservation, product longevity and life-cycle extension, packaging, and corporate performance.

IEEE 1680 and its product registration and verification system are part of the Electronic Products Environmental Assessment Tool (EPEAT), which is managed by the Green Electronics Council under a grant from the US EPA. The council will maintain a registry of computer products that meet IEEE 1680 criteria at www.epeat.net starting in June.

phone with Globalstar coverage will set you back about \$650, and it doesn't include minute usage. However, at least one company — All Road Communications (www.allroadcommunications.com) — will rent you one for \$19.99 per week. For using the device, though, you'll pay at least \$.95 per minute, and Iridium coverage starts at \$1.30 per minute. It's consid-

erably more than you're paying for the standard cell unit, but for world travelers and mountaineers, it may be worth considering.

COMPACT MOSFET DRIVERS INTRODUCED

Micrel, Inc. (www.micrel.com), which focuses on analog,



■ Micrel's new 6-A high-speed drivers target small power supplies.

high-bandwidth communications and Ethernet IC solutions, has launched a line of tiny, high speed MOSFET drivers. The MIC44F18/19/20 MOSFET driver family is a series of new 6-A devices targeted at power supplies and synchronous rectification applications operating at frequencies as fast as 2 MHz.

The drivers are tiny, single components for inverting and non-inverting solutions. They feature low power consumption and high-efficiency TTL and CMOS input logic level compliance. Output voltage levels can swing within 25 mV of the positive supply ground, in comparison to bipolar devices, which are only capable of swinging within 1 V of the supply.

These chips are capable of symmetrically sinking and sourcing current up to 6 A with a propagation delay of 10 ns and switching times of 15 ns. The ICs are available in volume with pricing starting at \$0.75 for quantities of 10,000.

HIGH-TEMP CAPS AVAILABLE

If you are designing something that will have to operate at elevated temperatures, you might want to take a look at the new line of high-temp capacitors from Arco Electronics (www.arco-electronics.com), designed for applications in areas such as oil exploration, oil service, military, aerospace, and high-voltage power supplies. The caps are designed and tested to operate from -55 to +200° C. You can get leaded high-temperature NPO and X7R dielectric encapsulated capacitors in sizes from 1515 to 7565. Epoxy-coated versions are available in sizes from 1515 to 10090, and surface-mount devices are also offered. **NV**

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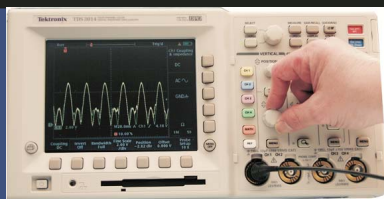
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- ✓ Patented circuit and design!

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This broadband radio monitors transmissions over the entire aircraft band of 118-136 MHz. The way it works is simple. Strongest man wins! The strongest signal within the pass band of the radio will be heard. And unlike the FM capture effect, multiple aircraft signals will be heard simultaneously with the strongest one the loudest! And that means the aircraft closest to you, and the towers closest to you! All without any tuning or looking up frequencies! So, where would this come in handy?

1. At an air show! Just imagine listening to all the traffic as it happens
2. Onboard aircraft to listen to that aircraft and associated control towers
3. Private pilots to monitor ATIS and other field traffic during preflight activities (saves Hobbs time!)
4. Commercial pilots to monitor ATIS and other field traffic as needed at their convenience
5. General aircraft monitoring enthusiasts

Wait, you can't use a radio receiver onboard aircraft because they contain a local oscillator that could generate interfering signals.

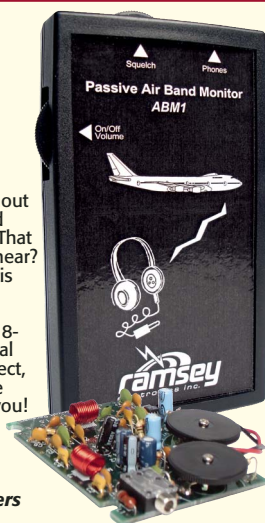
We have you covered on that one. The ABM1 has no local oscillator, it doesn't, can't, and won't generate any RF whatsoever! That's why our patent abstract is titled "Aircraft band radio receiver which does not radiate interfering signals". It doesn't get any plainer than that! Available as a through-hole hobby kit or a factory assembled & tested SMT version.

ABM1 Passive Air Band Monitor Kit

ABM1WT Passive Air Band Monitor, Factory Assembled & Tested

\$89.95

\$159.95



SPECIFICATIONS

Frequency Range:	118 MHz to 136 MHz
Receiver Type:	Patented Passive Detector
IF Frequencies:	None!
Receiver Sensitivity:	Less than 2 uV for detectable audio
Audio Output:	700mW, 8-24 ohms
Headphone Jack:	3.5mm stereo phone
External Antenna:	Headphone cord coupled 9VDC battery
Power Requirement:	2.25" x 2.8" PC Board
Dimensions:	2.5" x 4.6" x .9" Case
Weight:	4 oz. with battery

Digital Tuned High Performance Aircraft Band Receiver

New For 2006

- ✓ Rock solid dual conversion PLL receiver!
- ✓ Airport runway lighting controller output!
- ✓ 4 user memory scanner banks, 20 freq's each
- ✓ Full band scanner with skip and skip/timer modes
- ✓ Internal front panel speaker
- ✓ External antenna input, speaker out, headphone out
- ✓ Stylish and shielded black metal enclosure
- ✓ Available as a hobby kit or factory assembled & tested

Professional features at a hobbyist price! To begin with, we designed it with the latest technology, utilizing a rock stable synthesized PLL dual conversion receiver. We gave it superb image and adjacent channel rejection to allow you to lock onto the signals you want and not to be bothered by those you don't!

Once we got the RF portion designed we took a close look at the features desired in such a receiver. We gave it a neat 2x8 line LCD display to show you all the functions. Control of modes and setups is obtained through the front panel controls and confirmed on the LCD display. On/Off/Volume and Squelch controls are also provided on the front panel. We even gave it a front panel speaker in case you stack the lighting controller or something else on top of it! So far we've described the ultimate aircraft receiver that's not only the perfect field monitor for a hangar or airport manager's office, but for the serious enthusiast. Can it get any better than that? It sure can!

The top request we've had for a professional aircraft receiver was to embed automatic runway lighting control. Consider it done! The lighting controller follows the standard protocol for remote runway lighting. The pilot "keys" his microphone on the local CTAF channel for the specified number of times. All you need to do is set the receiver for the lighting control mode, then make sure the squelch is closed and will open on a suitably strong signal. Typically the number of "keys" or "events" according to the receiver control the lighting as follows: 3 events, 25% brightness; 5 events, 50% brightness; and 7 events, 100% brightness. The AR2's adjustable lighting timer sets turn-on duration to your needs. Includes the matching case and knob set and power supply. For the aviation professional that is not interested in building the receiver, the AR2 and the lighting controller are also available factory assembled and tested, ready to go. Just plug it in and you're all set.

AR2 Synthesized Aircraft Receiver Kit With Case & AC Power Supply

\$199.95

AR2WT Factory Assembled & Tested AR2 Synthesized Aircraft Receiver

\$269.95

AR2L Plug-In Runway Lighting Controller Interface Kit With Case & AC Power Supply

\$59.95

AR2LWT Factory Assembled & Tested AR2L Runway Light Controller

\$99.95



SPECIFICATIONS

Frequency Range:	117.975 MHz to 137.000 MHz
Receiver Type:	25kHz Step
IF Frequencies:	Dual Conversion PLL
Receiver Sensitivity:	10.7 MHz & 450 kHz
Image Rejection:	Less than 1 uV across the band
Adjacent Ch. Rejection:	Greater than -80 dB
Scanner Banks:	Greater than -40dB
Audio Output:	4, 20 frequencies each
Light Controller Output:	1 watt, 8 ohms
Power Requirement:	3 events, 5 events, 7 events output to controller
External Antenna:	12VDC, 500mA
Dimensions:	BNC female, rear panel
	5.55"W x 6.45"D x 1.5" H

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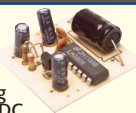


TS4 Tickle Stick Kit

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Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC



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BL1 LED Blinky Kit

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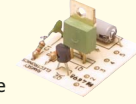


ECS1 Cricket Sensor Kit

\$24.95

Electronic Siren

Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.



SM3 Electronic Siren Kit

\$7.95

Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.



UT5 Universal Timer Kit

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Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.



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Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to 100 mA.



TD1 Encoder/Decoder Kit

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RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.



SA7 RF Preamp Kit

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Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.



TS1 Touch Switch Kit

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New For
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The FM100B kit is available in the standard US domestic 25mW version or export 1W version. (Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body outside the US).

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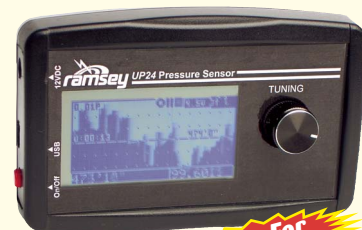
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New For
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We really did it this time! The UP24 is one of our most advanced kits to date, and an absolute MUST for anyone serious about the environment around us! But the applications only begin there.

The unique design allows unprecedented super high resolution measurements and display of absolute atmospheric air pressure. The UP24 senses ambient air pressure and critically calculates elevation with unheard of precision! Using a highly sensitive sensor and 24-bit A/D converter in a special noise-immune design, less than 1/3" of an inch of elevation resolution is achieved! YES, we said 1/3" of an inch! This high accuracy and resolution opens the door to a host of sophisticated environmental air pressure monitoring applications.

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We've talked about air pressure, now let's talk about elevation! The incredibly precise 24 bit A/D converter in the UP24 looks at the air pressure and converts it to elevation above sea level. In both graph and text, the elevation is displayed to a resolution of 1/3"! Yes, I said 1/3 of an inch! The applications for the super accurate elevation meter are endless. From watching and recording elevations during hiking trips to measuring and recording the wave heights on boats! Let your imagination take over from there!

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■ BY JON WILLIAMS

SPIN, BABY, SPIN

WELL, THIS MONTH WE'RE GOING TO WRAP-UP our intro series on the Propeller multicontroller, and I'm going to show you what I think is the best feature of the chip — the ability to run multiple processors at the same time, even when programmed in the high-level Spin programming language.

As I pointed out last month, I really don't have the patience to become very proficient at assembly language, and that fact has probably held me back on some projects. Not any more; the Propeller lets me (and you!) create complex, multiprocessor projects without having to learn assembly. Why would we want to do that? Well, let's say we have a device that needs to monitor and process sensors; how cool would it be to dedicate one of the Propeller's cogs to "background" monitoring of the sensors while another — perhaps the "foreground" program — takes care of real-time data display. That's what we're going to do this month, albeit with a fairly simple program that reads a potentiometer (in its own cog) and displays the value on a serial LCD.

To read the potentiometer, we're going to create an object called **rctime** that mimics the BASIC Stamp's **RCTIME** instruction. Easy enough, right? And as we're writing the code, we might as well include some convenient features, like the ability to run completely independent of our "foreground" program, and to scale the output value so the foreground doesn't have to.

Enough chit-chat, let's dive right in. Extract the archive and open the *rctime.spin* file, which I should mention was originally created by my colleague Beau Schwabe (also a

long-time BASIC Stamp user). The heart of this object is the **rctime** method.

```
PUB rctime(pin, state, zofs, div, rcAddr) | rc_temp

if lookdown(pin : 0..27)
    state := 0 #> state <#1
    zofs #>= 0
    div #>= 1

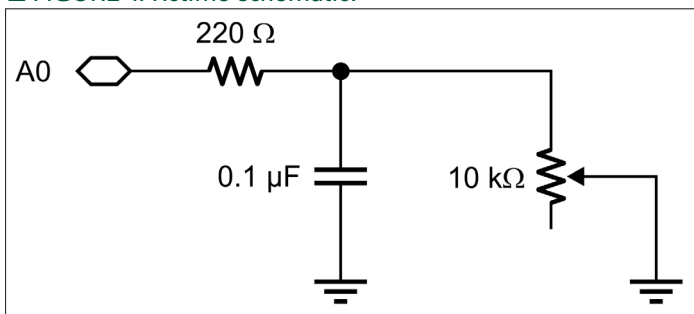
repeat
    rc_temp~
    outa[pin] := state
    dira[pin]~
    waitcnt(clkfreq / 2000 + cnt)
    dira[pin]~
    rc_temp := cnt
    waitpne(state << pin, |< pin, 0)
    rc_temp := ||(cnt - rc_temp)
    rc_temp := (rc_temp - zofs) #> 0
    rc_temp /= div

long[rcAddr] := rc_temp

if mode == 0
    quit
```

NOTE: All files mentioned in this article are located on the *Nuts & Volts* website at www.nutsvolts.com in the "stamp0606code.zip" file.

■ FIGURE 1. Rctime schematic.



We're going to make the **rctime** method public. This will let us call it manually (like we do with **RCTIME** in the BS2) or launch it into its own cog with the **start** method (we'll get to that shortly).

As you can see, this method has several parameters: *pin* (the I/O pin we'll use), *state* (the initial state, 0 or 1, of the capacitor in the RC circuit), *zofs* (zero offset that is used to compensate for the effect of the series pin-protection resistor), *div* (a divisor to scale the output) and, finally, *rcAddr* (the address of the variable that the method will update). We also have a temporary variable — *rc_temp* — that will be used as the storage space for the RC timing value before it is copied to the target variable.

Let's look at the code as it's called manually — like we do with the BASIC Stamp. Using the "standard" circuit as shown in Figure 1, and reading the value without a zero offset or

scaling divisor, the call to the **rctime** method looks like this:

```
pot.rctime(0, 1, 0, 1, @potVal)
```

Note that we're passing the address of (using the @ operator) the target variable instead of copying the return value of the **rctime** method — there's a very good reason for this. More on that later.

Now have a look at the **rctime** method code. We start by qualifying the pin input; this is a choice, of course, and I think it's a good idea not to connect an RC circuit to the EEPROM I²C lines or Propeller programming pins, so using 0..27 with **lookdown** prevents that. Remember that in Spin, **lookdown** returns a 1 to N value, not 0 to N-1 as with **LOOKDOWN** in PBASIC (or the Propeller's **lookdownz** method). By using **lookdown**, any non-zero return means that *pin* is within range; this is one of my favorite tricks with Spin, and it's certainly more elegant than:

```
if (pin => 0) and (pin <= 27)
```

... especially as **lookdown** (and **lookdownz**) allows a compound list with comma-delimited elements.

With the pin qualified, the next step is to make sure that the state, the zero offset, and the divisor are legal. This is very easily handled with the limit operators.

At this point, we get into the mechanics of the RC measurement. The first step is to clear the work variable — *rc_temp* — and then make *pin* an output at the *desired state*; this will charge (1) or discharge (0) the RC circuit. Using a 220-ohm series resistor and a 0.1 µF cap, the time required for charge/discharge is 110 µs; we'll go ahead and use 500 µs to account for component variations or a larger series resistor. Once the capacitor is charged, we make the pin an input, copy the system counter (**cnt**) value into *rc_temp*, and then wait for the pin state to change (this happens at 1/2 VDD).

To monitor the state change, we'll use the **waitpne** (wait until pins are not equal) method. This method lets us hold the program until one or more selected pins are not equal to the target value given. The syntax for **waitpne** is:

```
waitpne(target, mask, 0)
```

where *target* is the desired state of the I/O pins, *mask* is the value to be AND'd with the Propeller's inputs (the result will be compared to target), and 0 is for the port A pins. When the Propeller's pins AND'd with *mask* no longer match the *target* value, the method will fall through. Our program is just looking at one pin, and yet we can monitor as many as we need, up to 32. If, for example, we wanted to monitor a four-bit binary switch connected to A3..A0, and wanted to hold the program when the switch was set to %1010, the **waitpne** method would be set up like this:

```
waitpne(%1010, %1111, 0)
```

Note that %1111 is used as the *mask* so that all four pins, A3..A0, are used in the comparison.

In the **rctime** method, we only need to watch one pin, so we set the target by shifting the starting capacitor state left by the pin number. The pin *mask* is created with the decode operator (|<) — this works by shifting %1 left the number of bits specified (again, the pin number). If we were using pin A3 for the **rctime** I/O pin, the *mask* value would end up as %1000.

Okay, after the pin state changes, we'll subtract the original value of *rc_temp* from the system counter to get the number of counts elapsed during the discharge/charge cycle. The absolute operator (| |) is used to keep the return positive (when bit 31 of **cnt** is set, the value is considered negative by Spin math operations which are all signed). Now we can subtract the zero offset and divide the raw value by the divisor. The result is moved (as a long) into the target address; this is kind of like using POKE in some flavors of BASIC. Note that the target address is in main RAM; this will let us move the **rctime** method to its own cog and work in the background, since all cogs have (shared) access to the main RAM.

Before we get to that, though, you may be wondering how **rctime** terminates since all the code is wrapped in a **repeat** loop. When **rctime** gets called manually a global variable that is part of the object — *mode* — is left at zero. At the end of the **rctime** method, that variable gets checked; if it's zero the **repeat** loop is terminated with **quit**.

Now for some real fun ... how about we launch the **rctime** method into its own cog so that it runs happily "in the background" and constantly updates our target variable. Sound like fun? I can tell you that it is.

The **start** method of the *rctime* object handles the details:

```
PUB start(pin, state, zofs, div, rcAddr) : okay

  stop
  mode := 0
  okay := cogon := (cog := ↵
    cognew(rctime(pin, state, zofs, div, rcAddr), ↵
      @stack)) > 0
  if okay
    mode := 1
```

You may find it odd that the first thing the **start** method does is call the **stop** method. What we have to keep straight is that this code is assigned to a single object (*pot*, in our case), and if we restart that object we need to stop it first. And yes, we can have multiple versions of the same object in memory at the same time; if we were using them in "background" mode, each would be in its own cog, and we could stop or restart one without affecting any other.

The next step is to clear the mode variable — we don't want to let the top-object think that **rctime** is running in its own cog unless that actually happens. And we make that happen with the **cognew** method. With **cognew**, we can "launch" **rctime** into its own cog if a free cog is available. When that's the case (most of the time it will be), *cog*, *cogon*, and *okay* will get set to the cog number used by **rctime**. Once we know that **rctime** is up and running in its own cog, we can set *mode* to 1 to keep the method running and automatically updating our target variable. This is why we pass the target variable's address: once that's known to the method, it

can update the variable without any further interaction with the “foreground” program. I told you this was cool stuff.

Here’s what this boils down to for us regular folks: We don’t have to learn assembly to get background processes running! How cool is that? With eight cogs at our disposal, the world is brand new and wide open for just about anything we can imagine. I can tell you in all candor that I’ve been operating on a lot less sleep now that Spin has kicked in and started making sense; I’ve got 12 years of BASIC Stamp programs that I’m reviewing and porting to the Propeller.

Okay, let’s have a look at the “foreground” program (top level object) that takes advantage of **rctime**.

```
CON

_clkmode = xtall + pll16x
_xinfreq = 5_000_000

LCD_PIN   = 0
LCD_BAUD  = 19_200
LCD_LINES = 2

POT_PIN   = 1

VAR

    long potVal

OBJ

    lcd : "debug_lcd"
    pot : "rctime"

PUB main

    if lcd.start(LCD_PIN, LCD_BAUD, LCD_LINES)
        lcd.cursor(0)
        lcd.cls
        lcd.backLight(true)
        if pot.start(POT_PIN, 1, 1520, 642, @potVal)
            repeat
                lcd.home
                lcd.decVal(potVal, 5)
                waitcnt(clkfreq / 5 + cnt)
```

As you can see, it’s actually quite simple. We’ll use a Parallax serial LCD as our output device. If you prefer the SEETRON BPI-216 display — no problem. I’ve included an object called *Debug_BPI-216* that has the same methods as *Debug_Lcd*; all you have to do is change the baud rate to 9600 and the *lcd* object file; everything else is handled internally.

Look carefully at the **repeat** loop after the *pot.start* method is called. Notice how we don’t ever have to use the *pot.rctime* method? We don’t because the **rctime** method is running in its own cog and taking care of things automatically. And no, we don’t have to worry about attempting to read *potVal* from the main program while **rctime** is updating it; the Propeller hub allows only one cog at a time to access the main system RAM, so there won’t ever be a collision.

Before we wrap up this section, you may be wondering about the values 1520 and 642 for the *zofs* and *div* param-

eters. These values were derived empirically in three steps. The first step was to run the program with 0 (*zofs*) and 1 (*div*). I found on my setup that this returned a value of 1520 when the pot was turned to the zero position. Where does this come from? Instruction overhead and the small discharge delay caused by the 220-ohm resistor.

The next step is to insert 1520 into the *zofs* parameter and run the program again. The zero position should now be zero. Now we can turn the pot to the max position and note the output. In my case, it was about 64125 (with some small variation due to breadboard noise). I decided I wanted my pot to read 0 to 99, so I used 642 as the divisor. Step number three is to check it — bingo, the pot now reads 0 to 99.

STACKING IT ALL UP

Okay, there is one critical technical detail that we have to address before calling it a wrap this month. When a Spin program is running in its own cog, it needs a section of dedicated RAM — called a stack — to keep track of intermediate values (i.e., used during expression evaluation). Until the Propeller, determining proper stack size required a bit of luck, if not outright magic. Some time back, I was working with a small device that was multi-threaded, and the guidance for setting the stack for a new thread was to start big, then reduce the stack size until the thread crashed. Mmmm, I just didn’t feel quite right doing it that way. So why not just make the stack big and forget about it? Because it’s a waste of space, and even with all the memory available in the Propeller, it is still a small controller and we should use memory wisely.

Good news: We can use one of the Propeller’s cogs to determine the stack usage of another object. Now, I wish I was clever enough to have come up with this, but I’m not. I am clever enough to put it to use, though, and so are you, so keep this handy for when you start developing multi-cog projects. Included in the files is an object called *stack_monitor.spin*. This was created by a very sharp guy named Phil Pilgrim. Perhaps Phil’s name doesn’t ring a bell, but his work will. As a long-time friend of Parallax, he’s created some very interesting products including the M&M sorter, the color sensor AppMod, and recently, the Scribbler programming GUI. Phil brings his considerable programming skills to the Propeller and some really neat things are happening.

The *stack_monitor* is one of those objects that runs in its own cog; this allows it to keep tabs on a chunk of memory that another object is using as its stack. It must be installed (with its own **start** method) in the **start** method of the object that has the stack, providing the location of the stack, its size, and the MSB and LSB pins (connected to LEDs) that will provide stack usage output.

Here’s how to install it into the **rctime** object as the first line in the **start** method:

```
stackmon.start(@stack, 32, 23, 16)
```

This points the array called *stack* that has an initial size of 32. I’m using the Propeller Demo Board which has LEDs on pins A23..A16, so that’s what I’ll use as outputs. Now we go back to the top object and rerun it. On my system, LEDs

A19..A16 are lit, indicating the actual stack usage is 15 longs.

Okay, how does it work? The *stack_monitor.start* method fills the target stack with a known pattern (constant value called *FILLER*) and then launches the *monitor* method into its own cog.

```
PRI monitor(addr, size, ledMsb, ledLsb) | idx, used

outa[ledMsb..ledLsb]~
dira[ledMsb..ledLsb]~~

repeat
  used := 0
  repeat idx from addr to addr + size * 4 step 4
    used -= long[idx] <> FILLER

  outa[ledMsb..ledLsb] := used
```

As you can see, this method is actually quite small. It starts by clearing the LED pins and making them outputs before entering an infinite loop. Within the loop, the variable — *used* — is cleared and then the elements of the stack being monitored are scanned to see if they match the *FILLER* pattern. Now here's a really clever bit of code — have a look at the line that modifies *used*.

You see how there's a subtraction? This is odd, isn't it, since we actually want to add up the number of longs used by the object's stack. Well, here's why it works: The right side of the expression (after *=*) will evaluate as **true** or **false**. The key is that **true** is defined as -1 (\$FFFFFFF) in Spin, so when we subtract -1, it has the same effect as adding +1. Subtracting zero (**false**) has no effect. That's pretty cool, isn't it? I told you Phil was a sharp guy!

Darned nice, too, and very helpful in the Parallax forums.

Okay, I think that's about enough. After three months of Propeller work, you should have enough to get going — so get going! Remember to be patient with yourself; this is a big change from PBASIC and a whole lot of power is at your disposal; you just have to learn to use it. If you have a specific idea that you just can't make work, feel free to send it to me — we just might make another article out of it!

Until next time, Happy Spinning! **NV**

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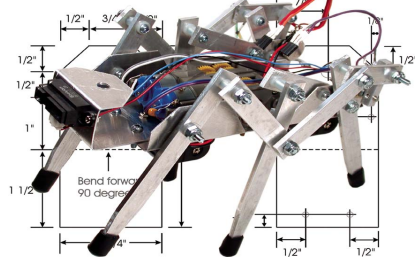
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PERSONAL ROBOTICS

UNDERSTANDING, DESIGNING & CONSTRUCTING ROBOTS & ROBOTIC SYSTEMS

■ BY PHIL DAVIS Co-written by Joe Stramaglia

ZEN AND THE ART OF ZIGBEE — PART 3

IN THIS LAST ARTICLE OF THE SERIES, I want to talk about using Zigbee in a Star configuration, which will allow you to drive multiple robots from your PC, addressing each one in turn, or sending a broadcast which all will respond to. I also want to show you how to “hack” the Freescale Sard card so you can take PWM directly off the card, giving you the ability to proportionally control two motors. In addition, we’ve also built a small robot as a demonstrator.

For those just joining, Zigbee is one of the new technologies designed to enable Wireless Personal Area Networks (WPAN) based around the new and emerging IEEE 802.15.4 standard. You might think of a WPAN (area) as your home or your backyard or perhaps your office space with you sitting at your PC and communicating

to your robot, telling it to stop, start, turn left, etc., and your robot reporting back various bits and pieces of status information.

So, let’s get started. The first thing to think about is what we have to do to modify the UART code that comes as a free demo which can be downloaded from the Freescale website.

Don’t forget, we want to use as much “off-the-shelf” software as possible and overlay the functionality we want.

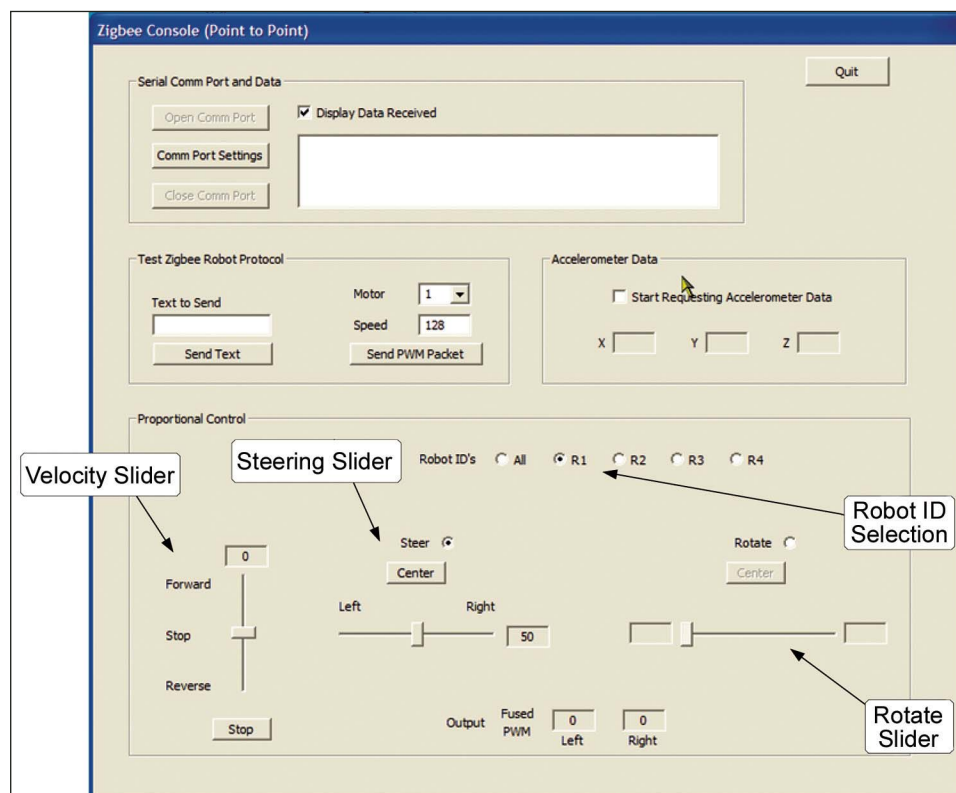
SMAC AND STAR

From a low level point-of-view, Freescale’s Simple Media Access Controller (SMAC) software — which supports simple point-to-point and star networks — provides us with the ability to have a single Sard module transmit data which is received by all other Sard modules within range. This being the case, all we have to do is arrange for a specific Sard card to intercept a message addressed to it and ignore all other messages.

PROTOCOL FOR STAR NETWORKS

Now for the addressing scheme. Last month, we introduced a very simple packet protocol for communicating the PWM values to each of the two motors of our robot where each packet contained the PWM for one motor. We have since taken the “PC to Robot” side of the protocol and modified it so that each packet contains the PWM values for both

■ PHOTO 1. Modified console showing new features.



motors. In addition, we introduced a scheme which will allow us to address an individual robot or broadcast a message to all robots. Eight bytes describe the packet for PWM:

Transmission from the PC to the Robot:

- One leading byte to identify the start of the packet and the address of a robot
- A command byte:
 - "P" for PWM data for the motors,
 - "X" or "Y" for other commands,
- One byte for direction of motor 1,
- One byte containing the PWM value for motor 1,
- One byte for the direction of motor 2,
- One byte containing the PWM value for motor 2,
- A trailing "%" to signify the end of the packet.

The leading byte contains our new addressing scheme, where an "*" represents a broadcast to all robots and an "+1" (a "a" (single quote)) represents robot1, an "+2" (a "-") represents robot2, and so forth (we are just adding 1 to the decimal value representing the ASCII char "*").

To make this work, we modified the Sard UART demo code to "sniff" the incoming byte stream for a "*", or a byte such as a "-" or a "+," which represents this particular robot's ID; all other bytes being thrown away until one of these is found. When found, we know we have the start of a packet and then the eighth byte can be checked for a "%" by way of validation. We can now be reasonably sure — at least for hobby purposes — that we have a packet that is meant for us. Additional processing of this packet involves testing if it is a "P" for PWM packet or some other command, and then taking appropriate action with the contained data.

There are some things to consider

here, for example. We should not broadcast a request for data to be returned, as a bunch of robots transmitting data at the same time would result in the receipt of garbage at the PC end. Instead, each robot should be polled in turn. However, we could broadcast PWM commands to stop and start and turn, etc., which would result in your robots performing "synchronized dancing." How cool would that be?

NEW CONSOLE

To accommodate these new changes to the protocol, we modified the console to include some additional robot addressing and rotational control.

As we will discuss later, we used a motor driver that takes a direction bit and a PWM value for each motor. The documentation for this driver states that damage might occur if you switch direction while the motors are running, so in the console code, we were very careful to make sure the motors were stopped before changing direction.

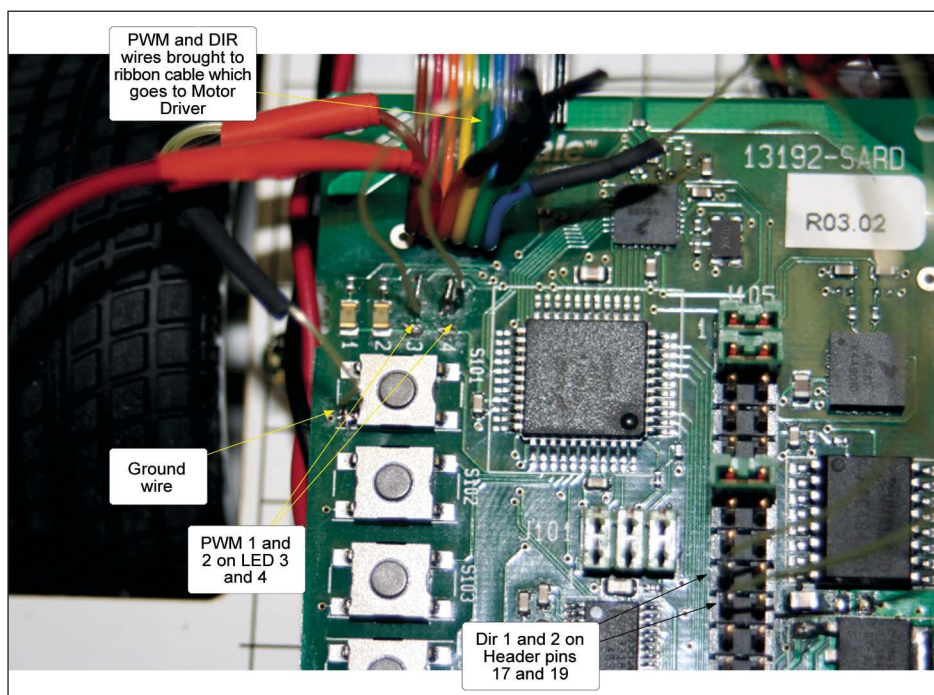
HACKING THE SARD

The idea behind hacking the Sard

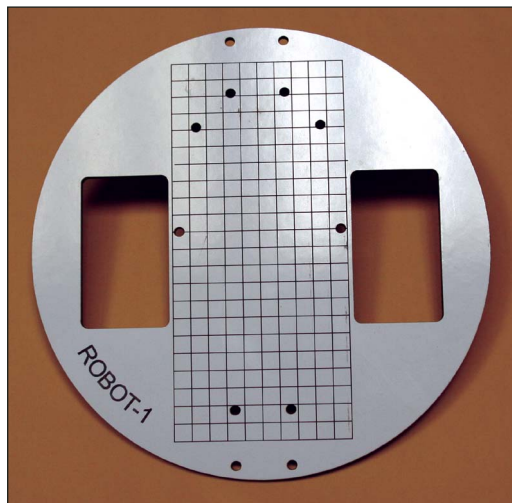
board was to remove the need for communicating serially with an additional processor as we did in last month's article. Since the Sard has a processor on board (a MC9S08GT60), for the purpose of executing the Zigbee stack, it makes sense to use that for all the processing needs of our robot, however, we still need a motor driver. The motor driver we chose was an inexpensive "Wirz #203 Dual Channel" obtained from Zagros Robotics (www.zagrosrobotics.com). This driver requires a direction bit and a PWM value for each of the motors, so we need two PWMs and two direction bits to pull off the Sard.

We downloaded the Sard schematic from the Freescale website (Doc# MC13192SARDUG) and, after some research, we found the four LEDs on the Sard are driven by the processor's PWM ports. We also needed two direction bits and we chose ports PTC0 and PTC1, which are surfaced on pins 17 and 19 of the 26 pin header on the board.

So, now what do we do? Nothing, except to remove LED3 and LED4 and solder some wires into those locations, as well as one to ground. These are surface-mount LEDs, so you will need a fine-tipped soldering iron and some sort of magnifying device



■ PHOTO 2. Close-up of Sard hack.



■ PHOTO 3. Laser-cut robot platform.

(at least I do). This will allow us to pull the two PWM values we need from the board to feed the motor driver.

Next, we solder two more wires to pins 17 and 19 of the header and feed those, as well, to the motor

RESOURCES

■ You can purchase the SARD board directly from Zigbee at this link: www.freescale.com/webapp/sps/site/prod_summary.jsp?code=13192DSK&parentCode=MC13192&nodeId=01J4F862825658166

■ You can download the free Code Warrior development tool at this link: www.freescale.com/webapp/sps/site/prod_summary.jsp?code=CWX-HXX-SE&parentCode=null&nodeId=01272694011860

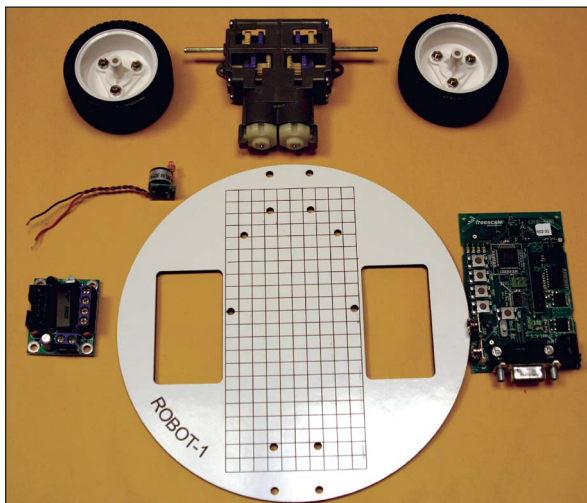
■ You can get online help on Freescale Zigbee at the following forum link: www.freegeeks.net/

■ You can also purchase Zigbee modules at the Maxstream website. www.maxstream.net/

■ You can purchase the Tamiya parts and more from Zagros Robotics. www.zagrosrobotics.com/Index.asp

■ You can have the robot platform cut at Rutherford Robotics: <http://rutherford-robotics.com/laser.html>

■ You can purchase the LiPol "BattSignal" from: www.battsignal.com/



■ PHOTO 4. Robot parts prior to assembly.

CAD program and had my buddy Jerry at rutherford-robotics.com cut it on his laser printer out of "white board" material (see Photo 3).

For the differential drive, I chose the Tamiya Double Gearbox and Tamiya Sport wheels and, after that, all that was left was something to

support the front and back. A caster wheel similar to a furniture caster would work fine (if you could get one small enough), however, Tamiya makes a ball caster which is just the perfect size and works great. On short notice, I was able to obtain all the Tamiya parts and the motor driver directly from the Zagros Robotics website.

In the UART code, we had to initialize ports PTC0 and PTC1 to output and then later, when a PWM value and direction bit was received, we set the ports accordingly — 1 for forward and 0 for reverse. Similarly, we had to initialize the PWM ports and then output the received PWM, where 0 was stop and 255 was full on in whatever direction the direction bit specified. All the references to LED3 and LED4 were commented out of the code so as not to interfere with the PWM.

All we need now is something to run all of this on ...

THE PLATFORM

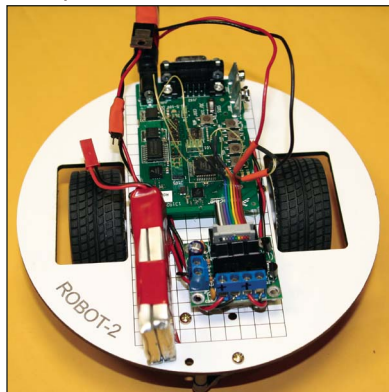
I am a big fan of circular bots with two wheel differential drive, the reason being, when they are stuck in a corner, the can rotate in place and simply drive away. For a surface to mount motors and the electronics to, I quickly drew up a simple drawing in a

support the front and back. A caster wheel similar to a furniture caster would work fine (if you could get one small enough), however, Tamiya makes a ball caster which is just the perfect size and works great. On short notice, I was able to obtain all the Tamiya parts and the motor driver directly from the Zagros Robotics website.

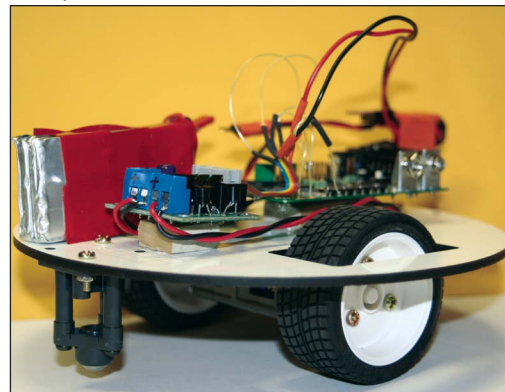
For a power supply, I am a fan of Lithium Polymer (LiPol) for a number of reasons. They are compact, small, and square; they have decent mAh values — typically 1,200 or 1,500 — and they can deliver high multiples of "C" amps (i.e., about 10+ times the cell's capacity). This means you could deliver 10+ amps in a pinch. A two-battery cell LiPol in series delivers from 8.4 volts on full charge, down to six volts when discharging and, since the motor driver we chose requires five volts for its logic, I used a 7805 to reduce the LiPol output to five volts.

The Sard card will accept from

■ PHOTO 5. The completed robot — top view!



■ PHOTO 6. Here's a side view of the completed robot.



five volts to 10 volts, so I fed it the voltage of the LiPol without change. (Just a quick caveat about LiPols: they are totally destroyed if discharged below about 2.6 volts per cell (three to be sure).) To ensure the Lipols were not discharged, I used a small device called a "Batt Signal," which issues a tonal warning as the voltage nears three volts per cell. Photo 4 shows a layout of some of the parts prior to assembly.

Since I had laser-cut the holes in the circular platform in all the right spots, bolting everything together and wiring up the electronics was the work of 30 minutes. When finished — for a quick hack and a quick build — it looked kinda cool (see Photos 5 and 6).

DID IT RUN?

You bet it did. It buzzed all over the place. Moving the velocity slider caused it to accelerate and decelerate, as well as move backwards when the slider was moved down past center.

I must say, the way I chose to control the robot — that is "sliders" — proved to be very difficult and sensitive (needed tuning), though I suppose you would get used to it. In any case, the premise of this project was not to build a remote-controlled robot, but rather to have an autonomous robot with either the intelligence on the PC or the intelligence on the robot, with information being passed back to the PC.

THINGS TO PLAY WITH

There are more available ports surfaced on the 26 pin header which can be used as either input or output, so for example, you might want to attach sensors, switches, or indeed control other devices other than the motors.

The simple protocol could have additional commands added to it, e.g., a "B" for beeping a buzzer or an "S" for requesting sensor data.

In this project, we did not build a second robot to show the "Star" network actually working, however, we did connect up additional Sard cards and had the commands they received passed out the serial port, which we then monitored. In this way, we were able to show ourselves that we could

talk to multiple robots at the same time.

I hope this project has given you some ideas and encourages you to try playing with Zigbee yourself. Let me know if you get the "synchronized dancing" working. **NV**

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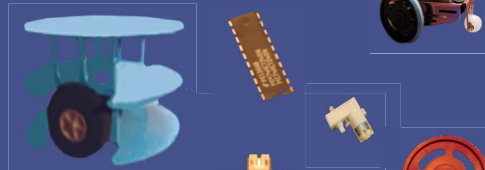
ABOUT THE AUTHOR

■ *Phil Davis has a computer science degree from British University and was a member of the Royal British Computer Society. Comfortable both with software and mechanics, he is passionate about doing things that have not been done (much) before. He can be reached at phild2@charter.net*

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WHAT'S UP:

Negative resistance demystified and lots of cool car gadgets.

WITH TJ BYERS

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments, or suggestions.

You can reach me at: TJBYERS@aol.com



Build a Lambda diode, play with it.



Automatic cigarette lighter switch.



Burned-out trailer taillight monitor.



Simple auxiliary battery charger.

FUN WITH NEGATIVE RESISTANCE

A while back in my Circuits 101 class for Electrical Engineering, the professor mentioned something about negative resistance. This was a totally new

concept to me — and he made almost no effort to explain it. It seems very strange, almost like having a negative weight or length. Can you please explain this phenomenon in more detail?

— Brian

In electronics, this is common. In fact, it's desirable. Without going to the math of imaginary numbers and the like, there is really no such thing as

negative resistance — as in there's no such thing as negative gravity. In both, it's all in how you define negative.

Ohm's Law states that as the voltage across a resistance increases, so does the current. It's a linear function. With negative resistance, on the other hand, the current *decreases* as the voltage *increases*, as shown in Figure 1. Several devices exhibit negative resistance, including neon lamps, tunnel diodes, and Lambda diodes, which you can make yourself from a pair of junction field-effect transistors (JFETs).

There are two types of field-effect transistors: those that operate in the enhancement mode and those that operate in the depletion mode. Enhancement mode means that the FET is forward biased (turned on), like a bipolar transistor. Depletion mode means that the FET is reverse biased (turned off), like a vacuum tube. JFETs are depletion-mode devices.

When configured as shown in Figure 2, the two transistors interact with each other and produce a negative-resistance Lambda diode. In fact, the curve in Figure 1 are actual measurements taken from this combination. Up to point A, the current increases as the voltage is increased. At point A, the diode current peaks and begins a decline from point A to point C, while the voltage continues to increase — negative resistance!

Want to play with it? For most applications, the diode is biased in the

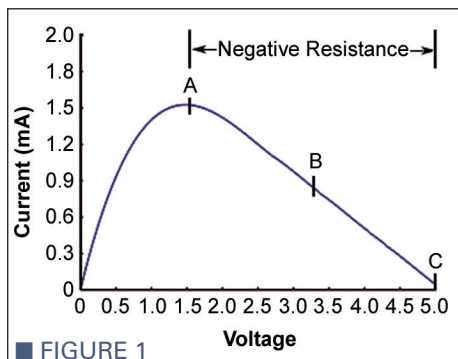


FIGURE 1

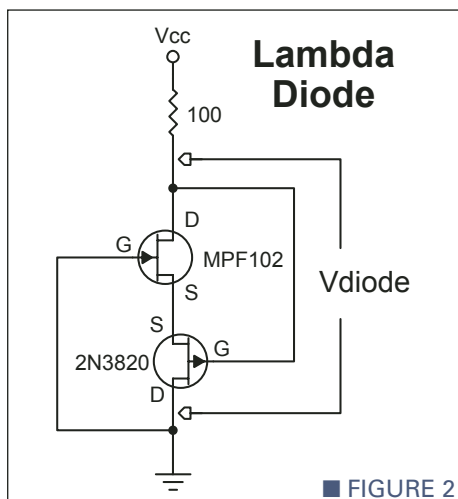
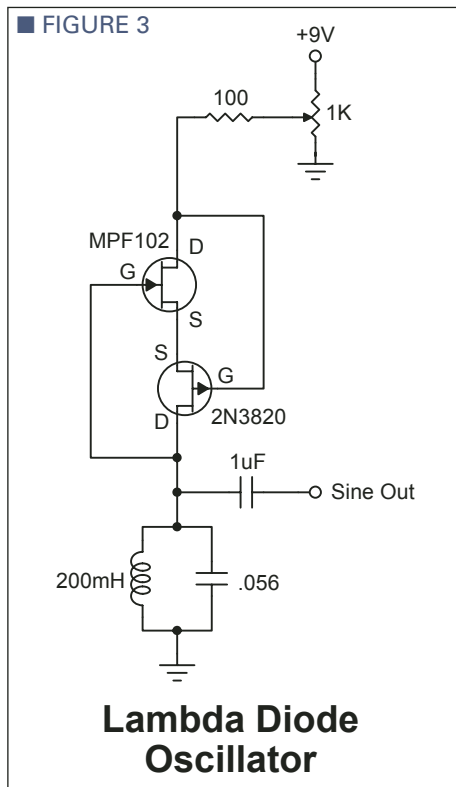
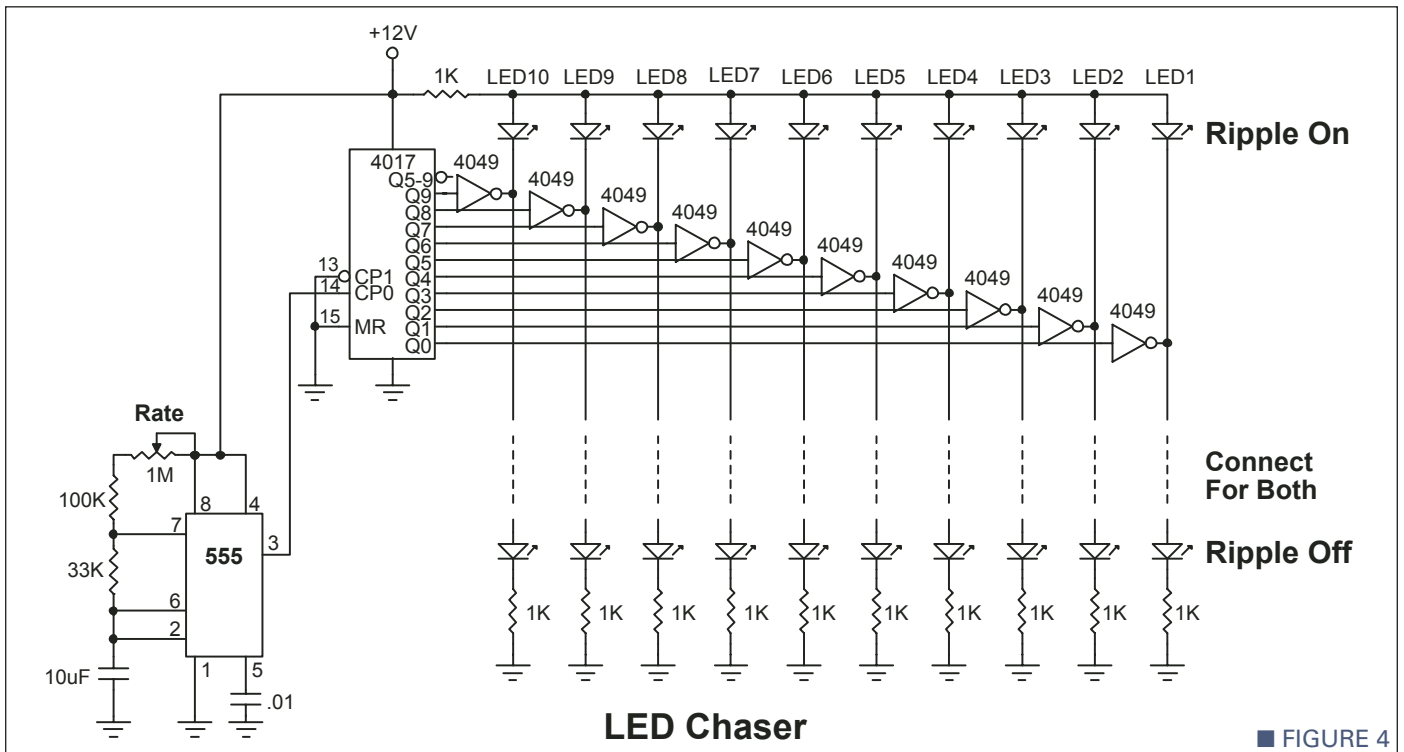


FIGURE 2



Lambda Diode Oscillator



middle of the negative-resistance slope, at point B. An example of a practical Lambda circuit is the sine-wave oscillator shown in Figure 3. All it takes is a Lambda diode and a tank circuit; this circuit should oscillate at 1 kHz with the values shown, but it can be easily extended to 100 MHz with the right tank values. The 1K potentiometer is used to set the bias of the diode because not all JFETs will land in the sweet spot at the same voltage.

WALKING LAMPS

Q I would like to attach 8 to 10 LEDs to a board and have them flash on and off in sequence. I have often seen such a display in art galleries. Can you suggest a way of doing this — perhaps using a 555?

— John Joyce
North Vancouver, BC Canada

A This is an easy design — if you use the 4017 decade counter as shown in Figure 4. This chip forces each output high in sequence each time the clock is pulsed by the 555 astable oscillator, and creates the “walking LED” effect you’re looking for. The Rate control determines the rate of the walk. If you would rather

have all the LEDs lighted with only one going off in sequence, use the bottom LED circuit instead. For a stunning visual effect, use both the top and bottom LED connections and interlace the LEDs. Being an artist, I’m sure you can come up with some interesting combinations.

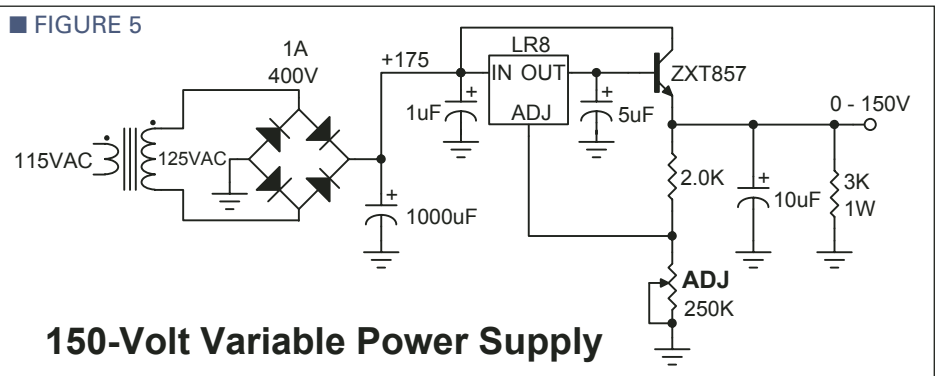
ADJUSTABLE HV POWER SUPPLY

Q I have a power transformer that can deliver 125 volts at 500 mA, and I want to use it to construct a variable 0-150 volt regulated power supply for some tube applications. Do you have a good circuit for this?

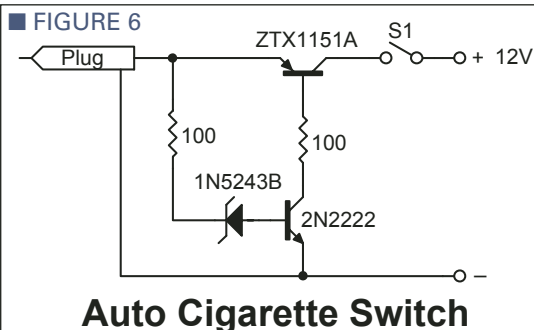
— Tony

A Trying to get 150 volts DC from a 125 VAC transformer is not easy because you don’t have a lot of headroom. For good regulation, you need some kind of voltage difference between the input and output voltages. Even without a load, the best you can hope for from this transformer is 175 volts — and that decreases as the load increases. Fortunately, you can get more current as the voltage is lowered; you should get maximum current somewhere around 120 volts and under.

With that said, here’s the best design I could come up with (Figure 5). The LR8 voltage regulator is a three-terminal device — like a 78L05 — that has an adjustable output voltage range of 1.2 to 450 volts. Unfortunately, the



■ FIGURE 6



Auto Cigarette Switch

LR8 can only supply 10 mA of current. Which is why the external pass transistor is needed. This transistor is configured as an emitter follower; it has very low voltage drop and will pass as much current as your transformer can provide. That is, it's not short-circuit protected as is the LR8 chip by itself — so be careful. Mouser Electronics (800-346-6873; www.mouser.com) has the LR8 in stock.

POWER ON DEMAND

RadioShack used to sell a gizmo which plugged into a car cigarette lighter and had a 12-volt accessory outlet. The electronics inside turned the outlet ON when the engine was running, and turned it OFF when the ignition key was turned off. There was no connection to the ignition wiring and it turned ON a couple of seconds after the starter cranking, to save all power to start the car first and save the appliance from fluctuating voltage. There was even a manual on/off switch. It was quite a clever design (plug and play, no wiring) — great for a cell phone charger, CD player, etc. But RadioShack has since discontinued it along with many other

goodies they used to sell. I wonder: Are there any old schematics left to build one?

— Dusan

A Not that I can find — but I have an idea of how they did it. When the engine is not running, the battery voltage is 12.6 volts. Crank to start, and the voltage drops to as low as

four volts. Once the engine is running, the alternator engages at 14.2 volts to replace the energy used to start the car. And there it stays until you turn the car off, after which the battery goes back to its 12.6 volts “wait” state.

What this gizmo does is monitor the battery voltage and turn the outlet ON when it exceeds 12.6 volts. I would do this using the circuit in Figure 6. The switch consists of just three parts: transistor, resistor, and a zener diode. When the voltage is below 13 volts — the breakdown voltage of the 1N5243B zener — the zener doesn't pass current, which means the PNP transistor is turned OFF. After the alternator is online, the lighter's voltage exceeds 13 volts and forward biases the 2N2222 transistor, which now turns ON the PNP.

The ZTX1151A transistor was selected for its low voltage drop (typically 230 mV) and high current (3A). Any PNP transistor can be substituted — so long as the collector current (IC) equals or betters your load requirement. What you have to look for is saturation (VCE (SAT)) voltage. For each volt that's dropped across the transistor, that's one less volt delivered to your load.

T-BIRD LIGHTS: THE SEQUEL

Q As an owner of a '68 Mustang for 32 years, I followed the T-Bird light series with interest. When the high-power circuit was presented, however, it took me but a moment to realize that it could not be made to work in an early Mustang. Like most cars of that era, the lights are rigidly grounded through the metal housings and metal sockets, and must be switched on the high side. Also, the 1157 lamp has two filaments sharing a common ground, so, if floating all the grounds was somehow accomplished, the parking lights would no longer function due to all the grounds being lifted by the sequencer. I hope this helps in some way.

— Tim Young

A As far as I know, the Mustang light fixture has to be modified to accept three #1157 bulbs. How do I know? I lived down the street from Shelby's Cobra Mustang modification facility in Torrance, CA in 1964. I saw those awesome 428 engines he was dropping under the hood — and the new electronics. Hence, my April '06 design. But, as you say, not everybody is into that much rewiring. So here's a circuit (Figure 7) for those car buffs who want to use grounded lamps.

If you refer back to the May '06 issue, you will see where I describe in detail switching a load on the high side. Here is a case in point. For the load to be grounded, the B+ side has to be turned on and off. Normally, this requires a high-side driver with off-set electronics. Fortunately, SCRs aren't so fussy. A single resistor from anode to gate is all you need to trigger the SCR on. The SCR doesn't care about either the anode or cathode relationship to ground — just the difference between them. Which is why I'm able to use a simple optoisolator — an NEC PS2501. This device comes in packages of one, two, and four isolators (PS2501-1, PS2501-2, and PS2501-4, respectively). This IC is also comfortable blinking on/off in Ontario winters, and is available from Digi-Key (800-344-4539; www.digikey.com).

As before, a 4017 is sequenced by

MAILBAG

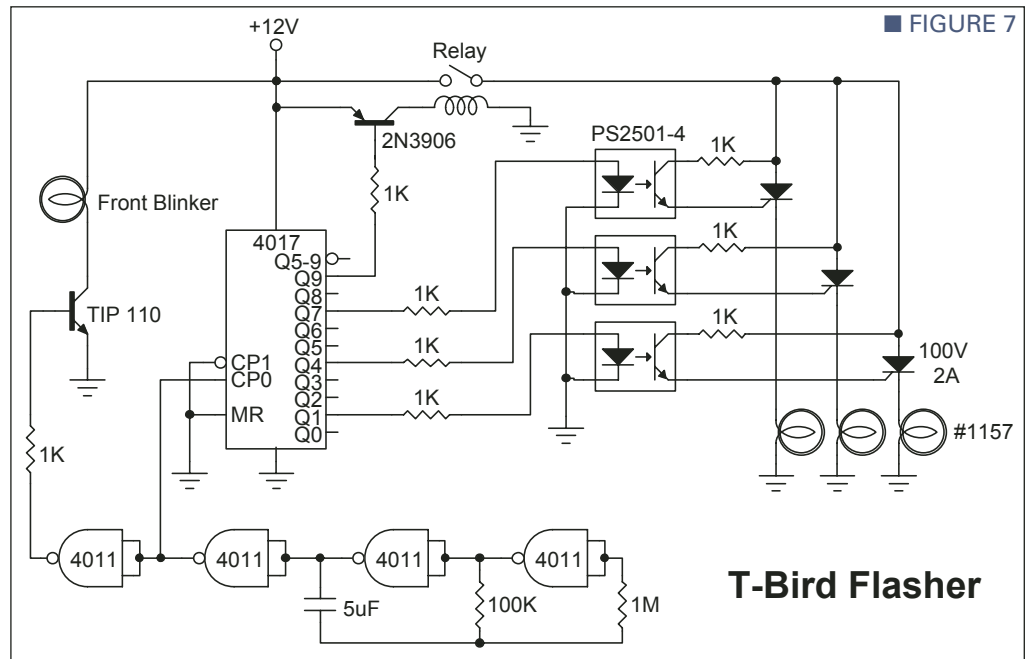
Dear TJ,

Your explanation of LS impedance is not quite correct. A loudspeaker is a complex electromechanical transformer coupling electrical power to sound pressure level power. It has a “primary” impedance (seen by the amplifier) defined by cone mass, cone suspension compliance, magnetic flux density, voice coil length and diameter, and air loading — to name the main ones. Even with a voice coil of zero resistance, the speaker would reflect a load impedance to the amplifier and take power.

But real voice coils have resistance and it turns out that the DC resistance is not that far off the rated AC impedance. One final point, you are right in saying that speaker impedance is nominal. An eight-ohm speaker typically exhibits an impedance varying from below 6 ohms to 30 ohms, depending on frequency.

— Roger Jones, P.Eng.
Vice President Engineering
George KELK Corporation
Toronto M3B 2T5
Canada

the 4011 astable oscillator. The LEDs inside the PS2501 are turned on one after the other, which, in turn, fires their respective SCR. The sequence rate is determined by the 5 μ F capacitor; smaller is faster. When the Q9 output goes high, it opens the relay and resets the SCRs, so that the sequence can start all over again. I also received a letter from a reader (*Dale Robbins, La Junta, CO*) who pointed out that this circuit can't be used with a vehicle that has a mechanical flasher because of the voltage interruption. Correct! The voltage has to come from the signal switch alone, and any flasher unit has to be removed or bypassed, depending on the make and model.



TRAILER LIGHT MONITOR

Q I want to create a device that you can connect to a trailer hitch wire harness that will tell the driver if the trailer lights are burned out or not. I am looking for a unit with a few probes that I could connect to the trailer hitch wires that would monitor for 12 volts and current flow at the same time. I will then develop some software to act on this input and display something like: Left trailer turn signal light is burned out or left trailer brake light is burned out, etc.

— Dave DiMenichi

A Can you live with an “ignition-on” lamp check? If so, I can really simplify your problem. That is, you only check the lights at start up with the lights turned off, and don’t monitor them 24/7. The circuit is shown in Figure 8. In this circuit, a very small current is applied to the lamps when the “Press To Test” button is pushed. If all is well – no open bulbs – all four OK lamps will light. Why? Because if the filament – which has a resistance of less than 100 ohms – is open, it will have a logic high instead of a logic low, and that LED won’t glow. This logic is fed into four 1N4148 diodes, which are the equivalent of a four-input AND logic gate where any fault lights the Alert LED. If you have

a defective bulb, the Alert lamp will light. Should you hardwire the push-button switch closed, you can follow the action of the trailer lights as you change turn switches and brake pedal – but it will take some visual translation.

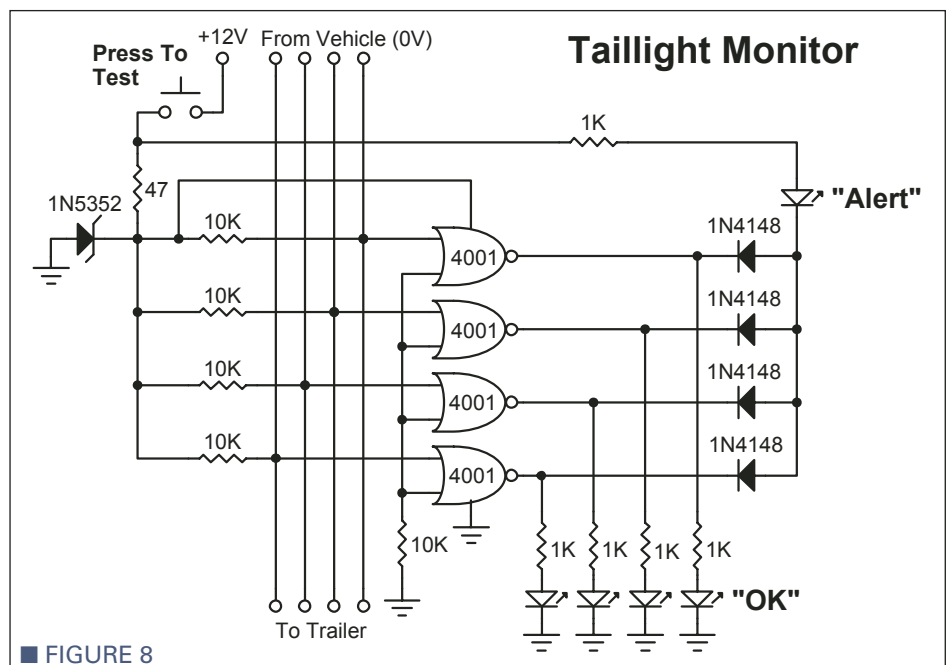
MORE TRAILER STUFF

Q I have a power inverter in the back of my truck powered by an auxiliary battery. I would like to keep it charged using the aux. connection of my trailer hitch

connector. I suppose I should use a steering diode, but I'm wondering if it might be better to use a MOSFET to reduce voltage loss while still preventing current backflow. How do I shut the circuit off, or would it shut itself off with the voltage difference from the alternator?

— Dan Henning
Chippewa Falls, WI

A What you need to do is treat the aux. outlet like any voltage source, and use it to charge the battery as needed. What



■ FIGURE 8



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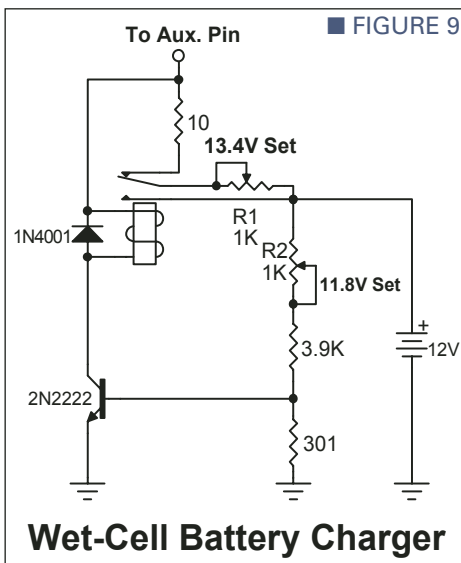
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I'd do here is use a SPDT (single pole, double throw) relay to toggle between a fully-charged battery and a battery in need of a charge – if charging voltage is available (can't happen with the engine turned off). That said, here is my solution (Figure 9). It's similar to a lead-acid battery charger I've done

in the past, but because of your automotive environment, I exchanged the comparator IC for a more rugged transistor.

The transistor monitors the voltage of the battery and turns on the relay when a charge is needed and off when the battery is fully charged. Potentiometers R1 and R2 set the trigger points. The best way to do this is replace the battery with a benchtop power supply and set the voltage to 13.4 volts. Set both pots to midrange and adjust R1 to the point where the

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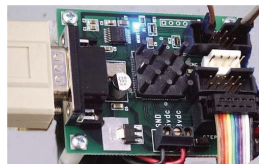
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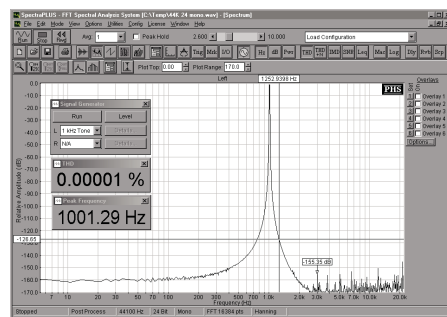
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relay just drops out. Reduce the voltage to 11.8 volts and adjust R2 so that the relay pulls in. The two adjustments are interactive, so you need to go back and forth until you get both set properly. Remove the power supply and install the charger between your trailer harness outlet and your auxiliary battery.

CNC SOFTWARE ON THE CHEAP

Q I'm looking for a cheap way to control a hobby CNC machine. I could use a microcontroller, but it would be time consuming and complicated to program all the motions in for each new part I wanted to make. Perhaps you know of some cheap software or maybe there's a way that I don't know about, like a way to program micros that is not so time consuming.

— Anonymous

A TurboCNC v4.01 (www.dakeng.com/turbocnc.html) is a robust, efficient CNC interpreter for driving machines with up to eight axes of motion. It is shareware (\$60 registration fee) and runs under DOS, which is easy to do if you're using Windows 95/98. If you are using Windows XP, you need to "Create MS-DOS boot disk" from File | Format, expand and copy the TurboCNC files to the floppy, reboot from the floppy, then run TurboCNC from the A:\> prompt. **NV**

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<http://nl.internet.com/ct.html?rtr=on&s=1,294v,1,i4rl,66pk,3qmh,cu1s>

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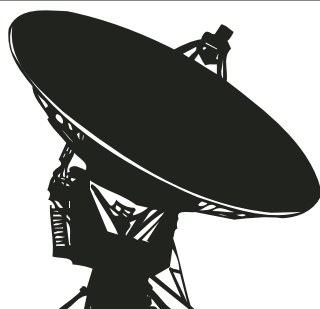
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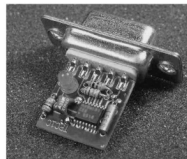
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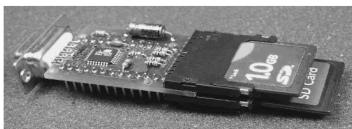
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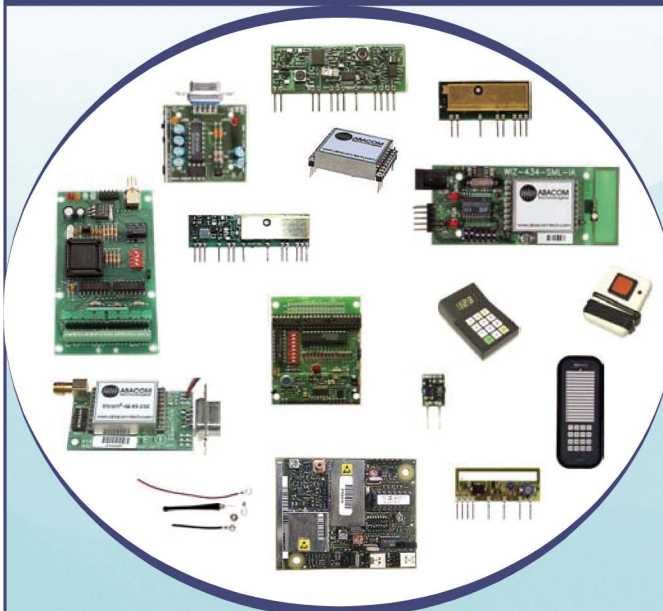
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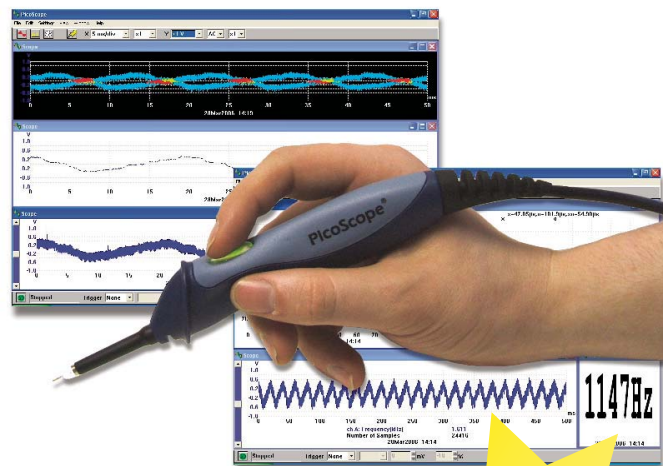
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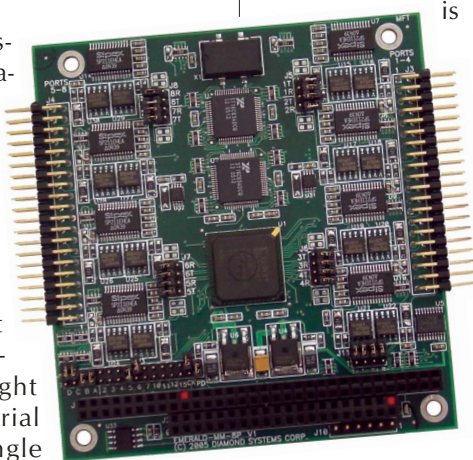
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Diamond Systems Corporation, a leading supplier of embeddable computer and I/O boards, has announced the availability of the Emerald-MM-8P PC/104 serial port module. Emerald-MM-8P offers eight multi-protocol serial ports on a single PC/104 module with complete software configurability. The board is designed to work in PC/104-expandable embedded computer systems running Linux, Windows, QnX, VxWorks, and DOS.

Each of the eight serial ports on Emerald-MM-8P can be individually selected for RS-232, RS-422, or RS-485 (both local echo and no echo) under software control; I/O addresses and interrupt levels are also programmable, with interrupt sharing available for any number of ports. Each port may further be enabled or disabled in software. All configuration data is stored in an on-board EEPROM and is loaded automatically on power-up. A utility program shipped with the board can be used to configure all options and store the configuration to the EEPROM.

For applications where fixed addresses are desired, four groups of preset addresses are available with jumper settings that override the programmed settings. In RS-422 and RS-485 mode, 150-ohm termination resistors may be selected with jumpers.



Emerald-MM-8P is based on the 16C654 quad serial port IC. This device contains four identical sets of registers, one for each port, and is compatible with the standard PC serial port. Each port contains 64-byte transmit and receive FIFOs to support high-speed data rates up to 460.8 kps.

Emerald-MM-8P offers eight convenient digital I/O lines. The direction of each line is independently programmable. Two I/O headers are provided, with four serial ports and four digital I/O lines on each header. The board operates on +5V only, eliminating the need for a +12V supply that is often required for serial port operation. The board is further tested and guaranteed for reliable operation over the extended temperature range of -40 to +85 C.

In quantities of 1-9 units, Emerald-MM-8P is priced at \$250. Volume discounts apply when purchasing 10 or more units.

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GP-22050-BASE allows you to access virtually any port that fits in 16 address/data lines and six control lines up to 50 MHz, reaching a maximum of 100 MB/s burst performance over the 16 kB internal memory depth. During operation, a built-in hardware accelerator reduces the control flow to a minimum to reserve the bandwidth for data transfer. Maximum continuous throughput of 48 MB/s is achievable, but actual continuous flow-through is held below the PC's maximum continuous throughput (~11 MB/s) — file size can be as large as your hard drive!

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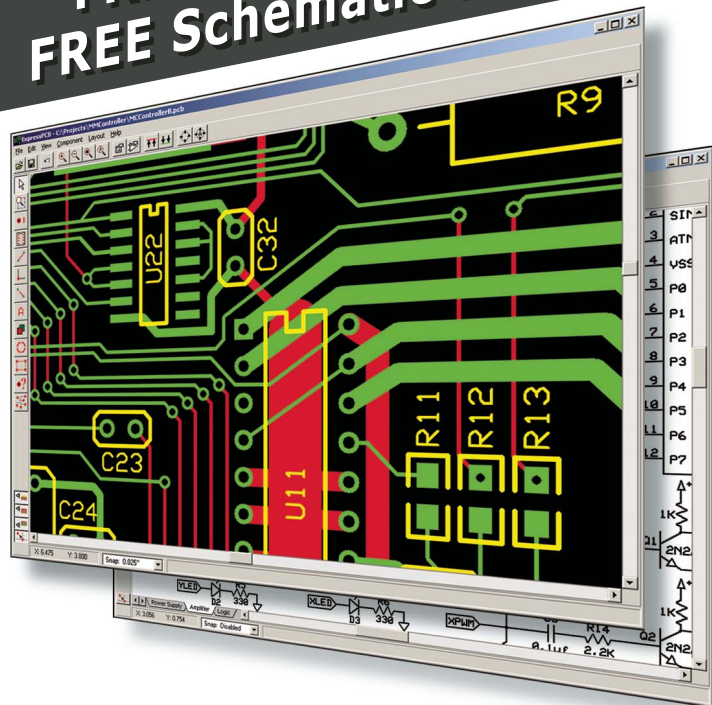
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■ THIS MONTH'S PROJECTS

Control Your World34

Panorama Mania38

"Mail Delivered" Detector44

■ LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

●●●● Beginner Level

●●●● Intermediate Level

●●●● Advanced Level

●●●● Professional Level

The RadioShack 22-812 multimeter is one of the most popular meters you will encounter. It touts many features found on much more expensive meters, one of which is an RS232 interface. When I first saw this meter, my geek alarms started ringing.

Wow! Just think of what I could do with a digital multimeter with a RS232 interface.

CONTROL YOUR WORLD

PART 1 — Interface Your PC to a Portable Digital Multi-Meter

As a natural-born geek, anytime I see something with an RS232 interface, my mind starts to wander. (My wife says I get this far away look in my eyes. My children have even used the "Yes Dad, and it even has an RS232 interface" excuse as a way to get me to purchase something for them.)

While the meter comes with its own software, just imagine the possibilities if you could interface the 812 with your own programs. In this arti-

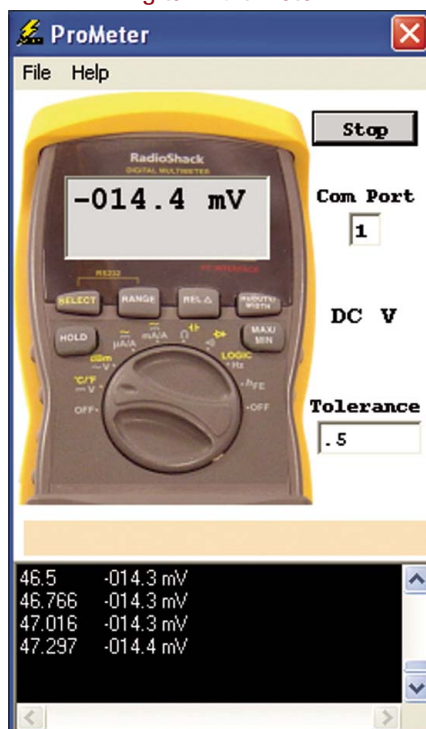
cle, we are going to do just that. I will show you how to connect and communicate with the 812. We will build a couple of reusable functions, and then program our own data logger.

The Interface

The physical connection to the 812 is made through a nine-pin female connection at the top of the meter with the included nine-pin serial cable. The 812 communicates at 4800 baud, eight bits, and no parity. Once connected to the meter, your program needs to raise DTR. The meter will then start to transmit data. One more thing is you must turn on the interface by hitting the Select and Range buttons at the same time, as shown in Figure 2.

To interface with the meter, we will use a programming language called Zeus. Zeus is a simple Windows programming environment that specializes in interface design. A special *Nuts & Volts* version of the software is available for free on the *Nuts & Volts* website (www.nuts)

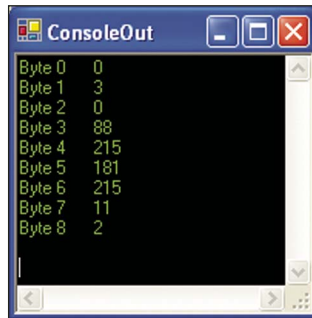
■ FIGURE 1. The RadioShack Digital Multimeter.



■ FIGURE 2. Closeup of the Select and Range buttons.



■ **FIGURE 3.** Displaying the nine bytes of data.



Byte	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
0	Mode							
1	Hz	Ohms	K	M	F	A	V	m
2	u	n	dBm	S	%	hFE	REL	MIN
3	4D	4C	4G	4B	DP3	4E	4F	4A
4	3D	3C	3G	3B	DP2	3E	3F	3A
5	2D	2C	2G	2B	DP1	2E	2F	2A
6	1D	1C	1G	1B	MAX	1E	1F	1A
7	Beep	Diode	Bat	Hold	-	~	RS232	Auto
8	Checksum							

■ **TABLE 1**

volts.com). It includes the application and source downloads, as well. The actual compiled applications are also provided for those who don't want to play with the code.

The meter data is transmitted in nine byte chunks we will call a packet. I have included a program called RS812_Program1.txt. This program collects the nine bytes of data and displays them on the console, as shown in Figure 3.

The heart of RS812_Program1 is a function called GetPacket. This function collects the nine bytes of data and places them in an array variable called Packets. Once collected, we can manipulate or display the data.

Table 1 shows a complete breakdown of the nine bytes of data.

The first byte tells you what mode or function the meter is in. Table 2 shows a list of these modes.

The actual data value is contained in bytes 3-6. These bytes represent the actual digit displayed. For example, byte 6 is digit 1, byte 5 is digit 2, byte 4 is digit 3, and byte 3 is digit 4. The actual bits map to the segments is shown in Figure 4.

To break down the data, take a look at RS812_Program2.txt. In this program, we collect the nine bytes of data then jump to one of the 17 handler functions based on the mode value (Byte 0). The 17 handler functions are as follows:

doWIDTH
doDUTY
doTEMP
dodBm
doCAPS
doDIODE
doLOGIC
doHFE
doFREQ
doOHMS
doCONT
doDCmA
doACmA

doDCuA
doACuA
doACVolts
doDCVolts

The functionality of each of these handler functions is pretty much the same. I broke them down so that you could easily change the way each piece of data is handled which will make it easy to customize.

The function GetDigits does all the real work. It builds the reading value based on the segment bits in bytes 3-6.

Once the data is collected and converted, the value is displayed in the Console shown in Figure 5.

Turn it Up

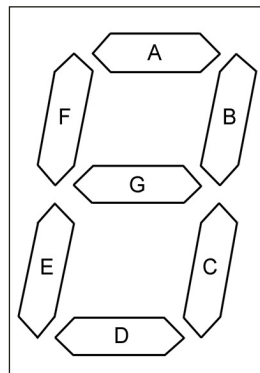
By this point, you should have a basic understanding of the protocol or, at the very least, you have run the sample programs. Now it's time for us to turn up the volume. Let's create a basic form interface that will allow us to display the information a bit more efficiently.

The Program RS8112_Program3.txt will display the form shown in Figure 6.

The program is simple to use.

STEP 1: Connect the meter to your PC.

STEP 2: Turn on the meter.



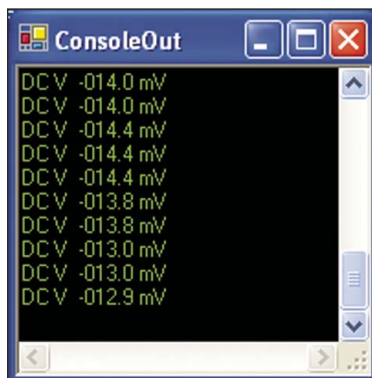
■ **FIGURE 4.** Bits map to the segments.

STEP 3: Turn on the RS232 interface.

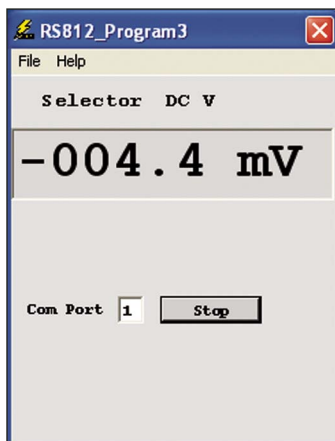
STEP 4: Enter the Com Port into the Com Port Field.

Mode	Function
0	DC V
1	AC V
2	DC μ A
3	DC mA
4	DC A
5	AC μ A
6	AC mA
7	AC A
8	OHM
9	CAP
10	Hz
11	NET Hz
12	AMP Hz
13	DUTY
14	NET DUTY
15	AMP DUTY
16	WIDTH
17	NET WIDTH
18	AMP WIDTH
19	DIODE
20	CONT
21	HFE
22	LOGIC
23	DBM
24	EF
25	TEMP

■ **TABLE 2**



■ FIGURE 5. Data collected and converted.



■ FIGURE 6. The form displayed by RS8112_Program3.txt.

STEP 5: Hit the Start/Stop button.

The only difference between Program 2 and Program 3 is that the display

information is sent to a few FormLabels. The program also monitors the FormButton to start and stop the program.

Experiment with the program. You could add a graphic bar to display voltage levels or even a simulated wave form based on the Duty Cycle.

As an example of a more

practical application, let's keep track of measurement changes, as shown in Figure 7. In Program RS812_Program4.txt, we added a few lines of code to the DoReadings function (see Listing 1).

What this code does is keep track of readings and, if it varies from the last reading more than the tolerance that you set, it will display the number of seconds since you started tests.

Keep in mind that the console trims itself a bit if more than 20,000 characters are displayed. If you want to keep track of a lot of measurements, use the File command to save the measurements to a text file.

Going Further

If you really want to get fancy, start experimenting with line graphics and plot your readings over time. Add File options to save and retrieve the data. Now that you have a working interface, it's time to let your inner geek out. Have fun. **NV**

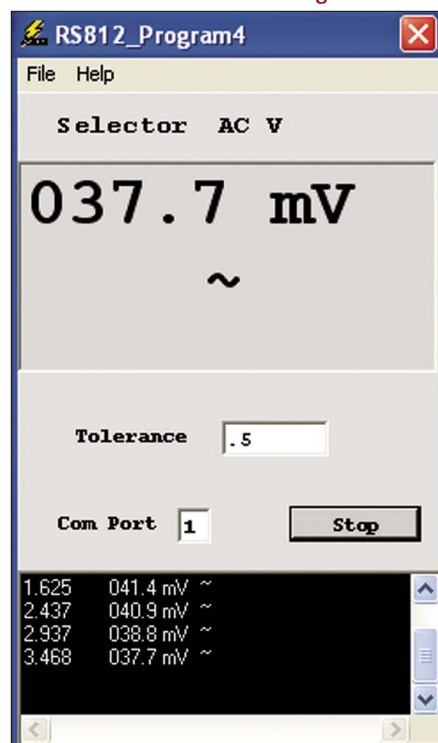
FOR YOUR INFO

■ As a bonus, I have built a couple meter applications with ZeusPro — one for the desktop and one for the pocket PC. Called ProMeter, they use bitmaps to display the meter and will log the readings to a file called MeterLog.txt. They are already built for you and can be found on the KRMicros website at www.krmicros.com/Development/ZeusPro/ZeusPro.htm

Listing 1

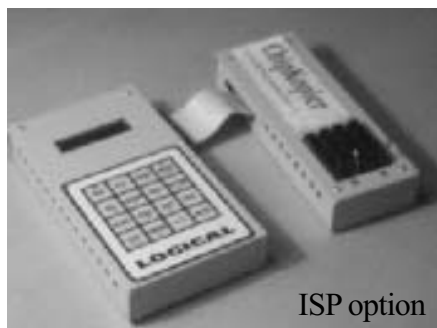
```
reading = res
if abs(abs(reading) - abs(lastreading)) >= FormTextBox(METER_TOL) then
    print float(int(Getms()-msstart)/1000),res
    lastreading = reading
endif
```

■ FIGURE 7. Keeping track of measurement changes.



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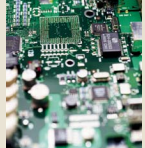
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■ **FIGURE 1.** Assembled shooting platform with cameras mounted into position.



PANORAMA

MANIA

Panoramic stitching programs that create one large photo from a series of overlapping photos can now be found in many digital image processing programs such as Microsoft Image Pro and Photoshop Elements, or as a stand-alone program like PanaVue ImageAssembler 3.0 (www.panavue.com), which was used to stitch the images presented in this article. The panoramic images that are created using these types of software packages are often stunning, but the quality of the end result is very much dependent on the caliber of the overlapping image acquisition procedure.

The most common way in which photographers obtain the overlapping images is to hand-hold the camera and — without tilting — take a series of rotated shots with about 20 to 30 percent overlap for each succeeding shot; a tripod is usually recommended for best results.

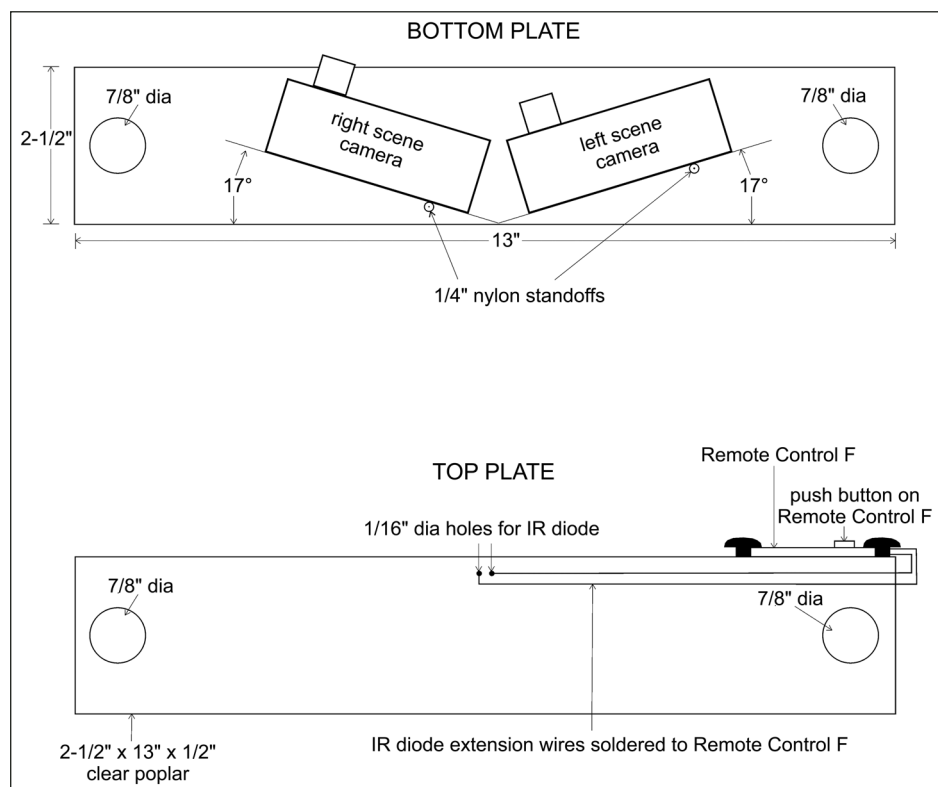
A number of things can go wrong with this approach. Principal among these is a lack of enough overlap, too much overlap, uneven horizons, tilted horizons, and in particular, each image is acquired at slightly different times creating movement anomalies (clouds, waves, vehicles, people, etc.) within the final stitched panorama.

This article presents simple

construction details for creating a hand-held shooting platform for two digital cameras that are triggered simultaneously, eliminating the temporal problem, and essentially eliminating all of the other problems listed above.

The two digital cameras used for this project were Pentax Optio 430 RS point-and-shoot types with zoom lenses and infrared (IR) remote capability. The shooting platform was designed with the zoom lenses of both cameras set to the widest angle possible (7.6 mm focal length — 35 mm format equivalent would be 37.5 mm focal length). A single Pentax Remote Control F was modified to simultaneously trigger the shutters on both cameras. Other digital cameras in the Pentax series use the Remote Control F and would make suitable substitutes for the Optio 430 RS. Many other manufacturers of digital cameras also use IR remote controls and because the modification to the remote control is so simple, it is very likely that it can be done on similar devices.

The assembled shooting platform with the cameras mounted is shown in Figure 1. The cameras are pointed towards each other, which is called being "toed-in" (they could also be pointed away from each other, which is called being "toed-out") in order to have the IR sensors that receive the external triggering code from the IR remote control as close together as possible. With the cameras pointed "in," the right camera shoots the left half of the panorama and the left camera shoots the



■ **FIGURE 2.** Construction dimensions for the top and bottom wood plates of the shooting platform. The location of the two holes for bolting the camera's tripod sockets to the bottom plate are not shown. The Remote Control F was attached to the top plate using two large-head wood screws with just enough tightening to hold it in place.

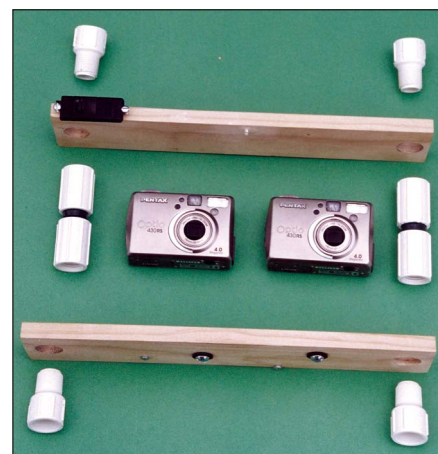
right half of the panorama.

The angle separating the two cameras controls the overlap between the two photos. It is easier to measure this angle as two angles (one for each camera) against a baseline (the back edge of the bottom plate of the shooting platform). For the two Optio 430 RS cameras with the zoom lenses, set to their widest angle and set to infinity focus (the landscape-mountain symbol) angles of 15° from the baseline, created about a 25% overlap, and angles from the baseline of about 17° created about a 12-1/2% overlap. These angles were determined from trial and error and not from calculations, so they are approximate. I simply attached the two cameras to the bottom plate of the shooting platform and rotated them "in" equally

from the baseline and then examined the overlap in the LCD screens.

Dimensions for the two shooting platform wood plates are shown in Figure 2. In order to facilitate construction, Figures 3 and 4 show the entire system as a set of unassembled parts from two different views. The plastic sprinkler-system plumbing parts needed to construct the shooting platform "handles" are listed and described in the caption for Figure 3.

The Remote Control F needs to be taken apart (see Figure 5) so that the IR diode can be removed from the printed circuit board and — with extension



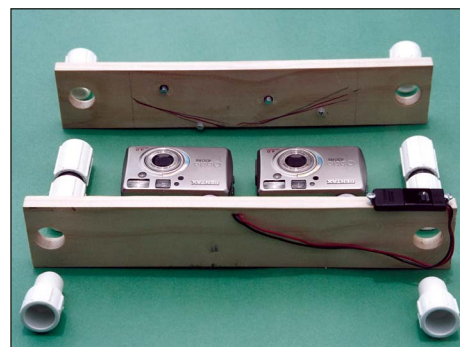
■ **FIGURE 3.** Disassembled shooting platform showing all of the pieces with the bottom of the two plates visible. Each handle of the platform is made from PVC pipe fittings and consists of the following parts (as described on the hardware store labels) from top to bottom:

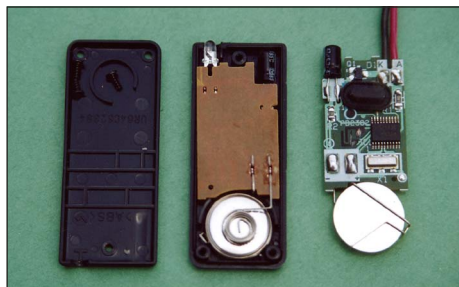
- 1/2-inch PVC Male Adapter (white)
- 1/2-inch PVC Female Adapter (white)
- PVC Riser Male 1/2-inch x close (black)
- 1/2-inch PVC Female Adapter (white)
- 1/2-inch PVC Male Adapter (white)

wires attached — positioned in front of the two digital cameras. Figure 6 shows a better view of the IR diode in relationship to the placement of the Remote Control F. I am right handed, so placing the Remote Control F on the right topside of the shooting platform makes it easy for me to trigger the two cameras with my index finger while holding onto the right pipe "handle."

Photo 1 shows two raw digital images (top) obtained by the cameras and the intermediate product (bottom) from stitching the left and right images together using the Panavue Image

■ **FIGURE 4.** Another view of the unassembled pieces shown here with the top of the two plates visible. You can see the 1/4 inch bolts that connect to the camera's tripod sockets, as well as the standoffs used to position the cameras on the bottom plate. Also visible on the bottom plate are line markings that I made, indicating the back edge of the mounted camera's positions, so I could roughly measure (with a protractor) the various baseline angles for different percent overlaps.

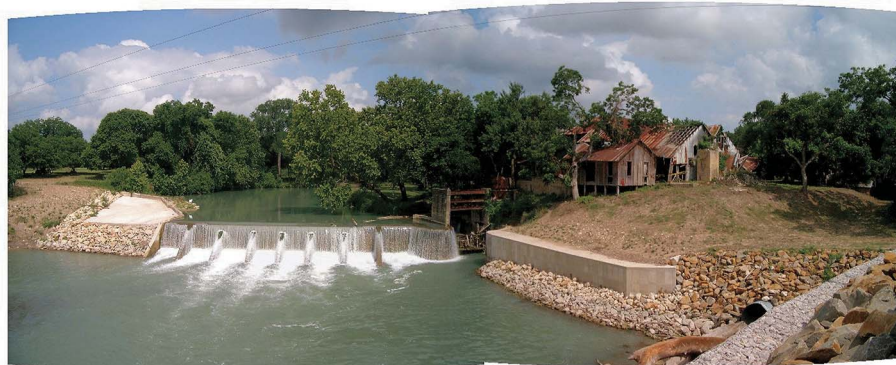




■ **FIGURE 5.** The innards of the Pentax Remote Control F are shown in this photograph. I took apart two Remote Control F units to make this photograph; only one is needed for the shooting platform. The left image and the center image show the two sides of a single Remote Control F case. The right image shows the circuit board as viewed in the center image after it has been flipped over, and the IR diode removed and replaced with the two wires that allows the diode to be placed on the shooting platform between the two cameras. Note that the anode and cathode on the circuit board are clearly marked (A and K). Use a permanent marker to mark either the anode or cathode on the IR diode before removing it from the circuit board.



■ **FIGURE 6.** This view shows the relationship of the Remote Control F to the IR diode positioned in the middle of the top plate of the shooting platform. A small piece of aluminum sheet metal (1/2 inch x 1/2 inch and not shown in this photo) placed in front of the IR diode ensures that more of the IR signal will be reflected back to the camera's IR sensors.



Assembler 3.0 software. The final cropped panoramic image after automatic contrast stretching, automatic color balancing, automatic color saturation, and sharpening in Paintshop Pro 7 is shown in Photo 2. The stability and fixed geometry of the shooting platform allows scenes to be acquired with a very small amount of overlap. The images in Photo 1 were overlapped by only about 12-1/2%, which is useful because smaller overlap results in final wider panoramic images.

The numbers below show what happens to the size of the images (in pixels) for each stage of the process shown in Photos 1 and 2.

Photo 1

- Top left JPG image is 1712 x 2304 or 3.94 MB
- Top right JPG image is 1712 x 2304 or 3.94 MB
7.88 MB
- Height-to-width ratio of both the left and right JPG images is 1:1.35
- Bottom stitched image is 1643 x 3974 or 6.48 MB

■ **PHOTO 1.** The top left image and the top right image (old Luling mill on the San Marcos River, TX) are the original images obtained by the two Optio 430 RS cameras mounted on the shooting platform. The bottom image shows the intermediate stitched output from PanaVue Image Assembler 3.0.

■ **PHOTO 2.** This is the final cropped panorama after the intermediate stitched panorama shown in the bottom half of Photo 1 was color balanced, contrast stretched, saturated, and sharpened.

Photo 2

- Cropped stitched image is 1396 x 3916 or 5.47 MB
- Height-to-width ratio of the final stitched panorama is 1:2.81
- Printing on 8-1/2 inch x 14 inch paper with a small margin results
- In a 4.95 inch x 13.875 inch panorama

Photos 3 through 6 are examples of panoramas shot with the individual scenes overlapping up to 25% and assembled using PanaVue Image Assembler 3.0. These were some of my first attempts and, although I used different software packages to stitch the individual images into panoramic views, some packages didn't work well with scenes obtained with less than 25% overlap. Only PanaVue Image Assembler 3.0 consistently produced acceptable stitched images from individual scene pairs with as little as 12-1/2% overlap.

Although it is possible to configure a shooting platform with three cameras (I have done this with three electronically triggered film cameras), there are a number of drawbacks to such a system. The wider field-of-view makes framing a little more difficult, and over such an extended area of coverage, variations in lighting often produce images that are quite different in tone and contrast. All of the other variables such as keeping an even horizon, tilting, and sometimes focus are more difficult to control. Print size involving longer, narrower images may also be a problem for some printers that don't accept long length paper stock.

Overall, the two camera setup described here yields excellent final panoramas. Printing on 8-1/2 inch x 11 inch paper produces panoramas that will fill a standard 4 inch x 10 inch panoramic frame and, for those desiring somewhat larger prints, 8-1/2 inch x 14 inch legal paper will yield panoramic reproductions that are slightly smaller than 5 inches x 14 inches. The system is light, compact, easy-to-use, and is now essential gear when I travel. **NV**



■ PHOTO 3. This is a panorama of "tubers" floating under the Hopkins Street bridge spanning the San Marcos River in San Marcos, TX. The stitching worked well in spite of the differences in illumination. Because of the moving tubers, this would have been an impossible shot using the single handheld camera method.



■ PHOTO 4. Further downstream from the bridge shown in Photo 3, the twin camera system captured this view of the San Marcos River Park. Irregular patterned features, such as foliage, tend to stitch better than regular features exhibiting straight edges.



■ PHOTO 5. This panorama shows the dam on the Guadalupe River in Seguin, TX.



■ PHOTO 6. The bridge next to the Seguin dam with a large oleander bush growing alongside illustrates some of the deformities you will occasionally encounter with the stitching of subjects that exhibit strong geometries — look to the right of the bush and about midway in that section of the bridge.



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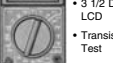


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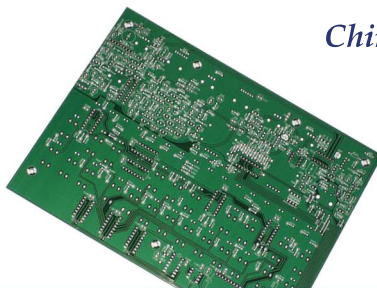
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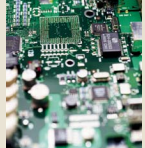
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Have you ever made multiple trips to your mailbox hoping the mailman had delivered that important letter or even better, that long awaited check?

This handy gadget will end those many unfulfilled trips and indicate via a lit LED and/or sound alert that your mail has been delivered. After you pick up your mail, you simply press a reset button and your Detector is ready for the next day's mail delivery.

"MAIL DELIVERED" DETECTOR

The Detector consists of a transmitter located in or by your mailbox, and the receiver can be located anywhere else you desire, probably in a room where you spend most of your time. The Detector I built for myself does not contain a "sound alarm," but one may be easily added if you need it.

The heart of the Detector is the 432.9 MHz transmitter and receiver modules from Reynolds Electronics. The receiver module is a very sensitive super-regenerative receiver, while the transmitter has a 16 dBm output which may be easily amplitude- or pulse-modulated.

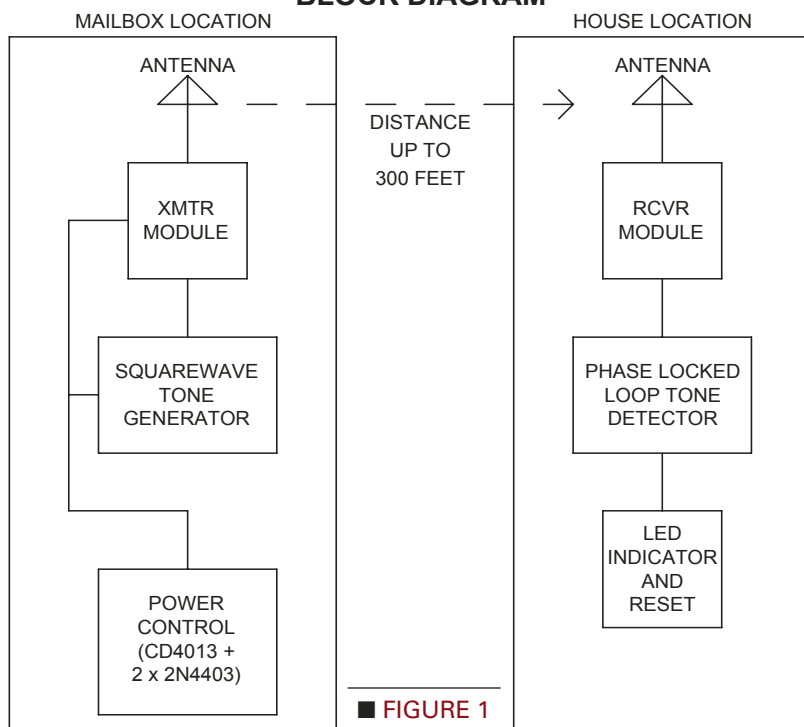
Each module is only \$8.50 and can be ordered over the Internet.

In my first prototype, I used an old remote control transmitter and receiver module from a remote controlled car operating at 27 MHz. That frequency is quite noisy because it is in the middle of the CB band. Although the prototype worked quite well because of key features in the circuit, the Reynolds modules are much better at 432.9 MHz.

Hiding Out

Figure 1 shows how simple the Detector is. The transmitter module

BLOCK DIAGRAM



■ **FIGURE 1**

■ **FIGURE 2**



■ **FIGURE 3**



is mounted in or on the mailbox (see Figures 2 and 3). I mounted mine in the newspaper box which sits right beside my mailbox. The magnet-operated switch is located on either side of the mailbox door opening, while the actuating magnet is located on the door itself (see Figure 4).

The receiver module can be located anywhere within 300 feet of the mailbox (i.e., somewhere inside the house). When the mailbox door is opened, it turns on the transmitter and tone generator for approximately 30 seconds. The receiver detects the tone after it has been present for approximately 15 seconds and latches the Detector's red LED on until it is turned off by the reset pushbutton switch.

Power to Last

Since the transmitter is powered at all times by a nine-volt battery, when not actuated by the mailbox door being opened, it must have a very low current drain. This is made possible by the use of a CMOS CD4013 dual RS flip-flop chip and one of the 2N4403 transistors. When the mailbox door is closed, the current drain is one microamp. If the mailman inadvertently leaves the door open, it drains nine microamps. During the 40 seconds or so the transmitter is activated, the module draws approximately eight mA.

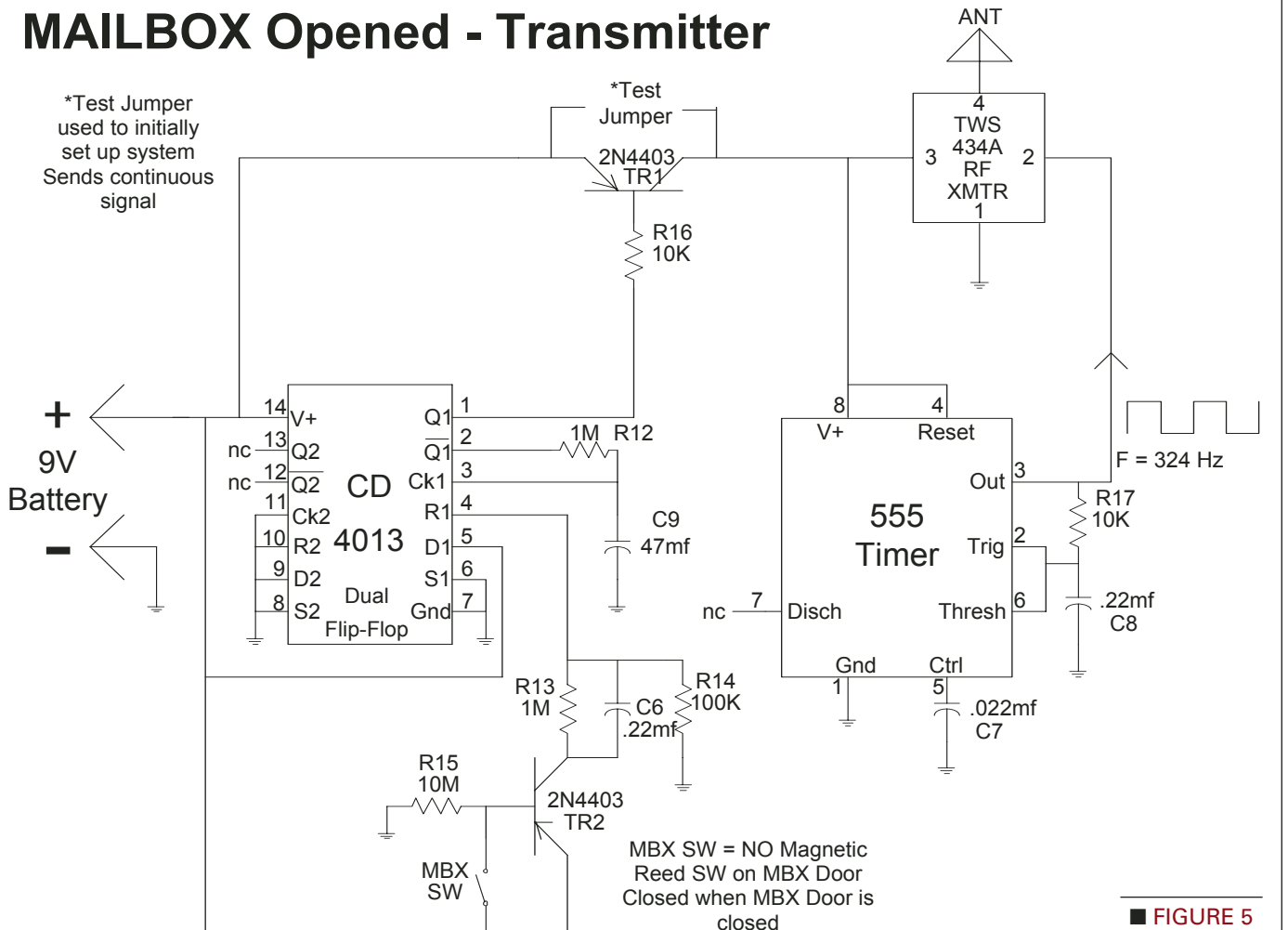
At this rate, the nine-volt battery should last between six months to a year. Although I use the nine-volt bat-



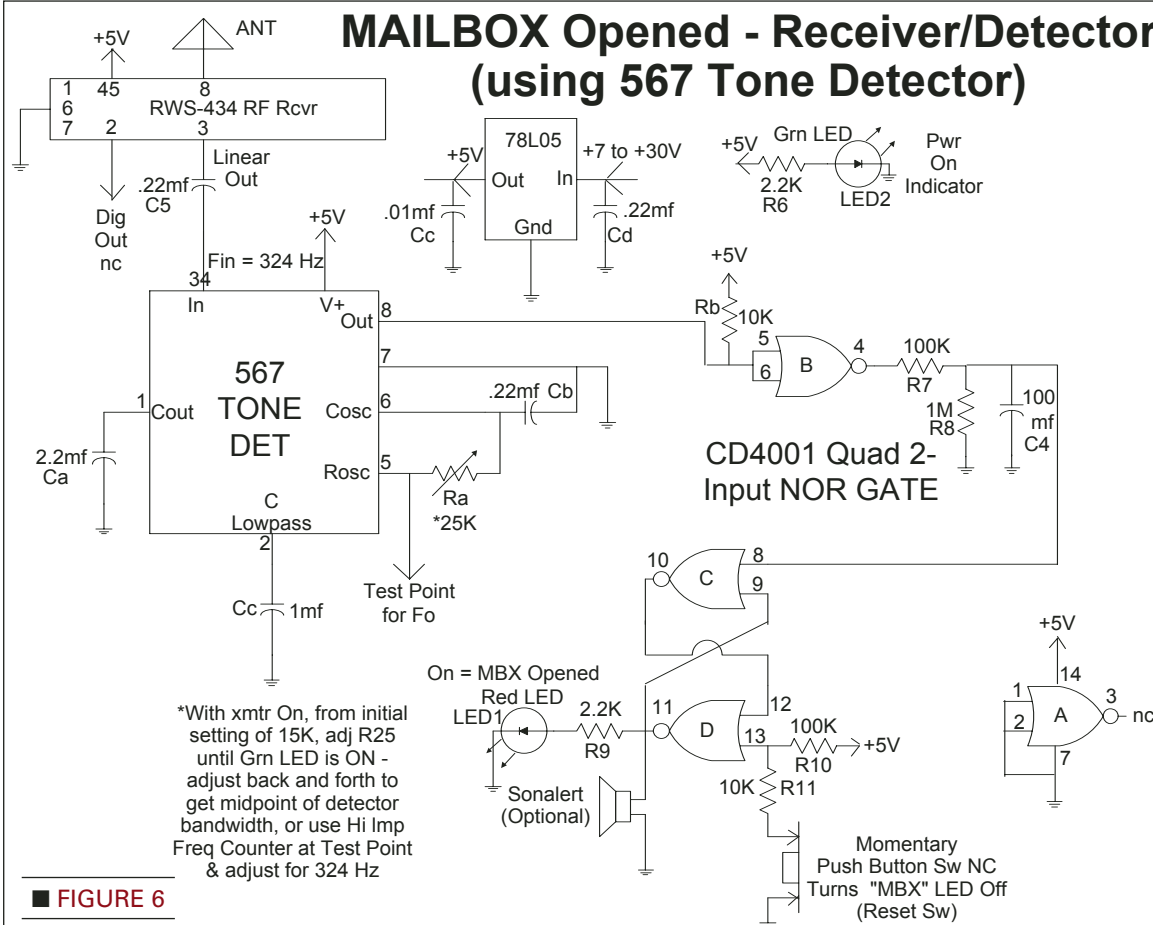
■ FIGURE 4

tery to power the transmitter, a nine-volt solar panel could also be used. All Electronics has a perfect solar panel for

MAILBOX Opened - Transmitter



MAILBOX Opened - Receiver/Detector (using 567 Tone Detector)



■ **FIGURE 6**

transmitter. Figure 5 shows the schematic of the transmitter unit.

Operation

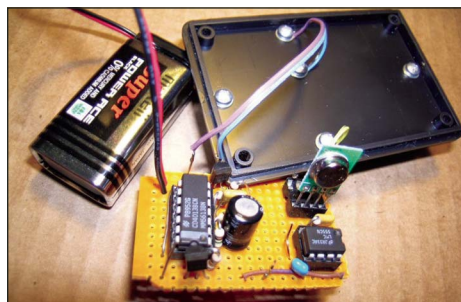
When the mailbox door is closed (or has been opened longer than the transmit time), reset pin R1 (pin 4) of the CD4013 is low and output pin Q1 (pin 1) is high, keeping transistor TR1 turned off (no power to the transmit module or to the 555 tone generator). Q1 “not” (pin 2) is low and is also passed to Clk 1 (Pin 3). This is the flip-flop set condition.

When the mailbox door is opened, a positive pulse is sent to reset pin R1 (pin 4). This immediately resets the flip-flop making Q1 low and Q1 "not" high. That turns on TR1 and supplies power to both the transmit module and the 555 tone generator which sends out the 432.9 MHz pulse modulated signal at approximately 324 Hz.

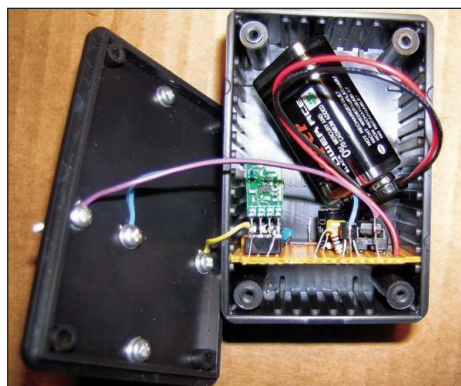
The high on Q1 “not” starts charging C9. After approximately 40 seconds, the high on Clk 1 causes the low on S1 (pin 6) to reset the flip-flop again, making Q1 high and Q1 “not” low, putting the circuit back to idle condition.

The receiver must be turned on at all times, so it is powered with a nine-volt wall-wart. Any voltage from 7 to 30 volts is acceptable here because of the 78L05 voltage regulator in the unit. Figure 6 shows the schematic of the receiver which uses an LM567 tone decoder. The receiver detects the tone sent out by the transmitter, and after

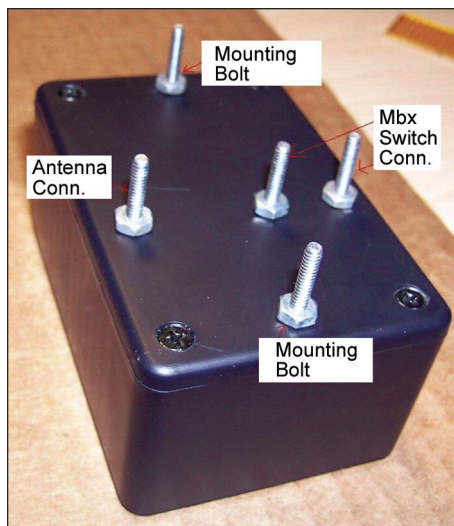
FIGURE 7



■ **FIGURE 8**



■ **FIGURE 9**



15 seconds or so of tone, the red LED and/or Sonalert are turned on indicating mail delivery. The red LED and/or Sonalert are turned off again by pushing the reset button. Since I did not have a coaxial power connector on hand, I used an RCA phone plug for the power connection to the unit. The parts list contains a suitable coaxial power connector.

CD4001 sections C and D are set up in a flip-flop configuration, where a previous high from the reset pushbutton has resulted in pin 10 being high and pin 11 being low. This keeps the indicators off. The LM567 tone detector chip is tuned to detect a tone of approximately 324 Hz. When that tone is present, the steady low at the output of the LM567 is inverted to a high by CD4001 section B. This high begins to charge C4.

When C4 is charged, it "sets" the CD4001 C and D flip-flop, turning on the red LED, the Sonalert, or both. This charge time is approximately 15 seconds, and prevents any kind of random signal from activating the indicators. The LED and Sonalert will remain on until the pushbutton reset switch is pressed putting a momentary high on CD4001 D pin 13 causing the flip-flop to reset, turning off the LED and/or Sonalert.

Construction Notes

Both the transmit-

ter unit and receiver unit were breadboarded on phenolic vector board cut to the proper size to fit nicely into the two Hammond plastic boxes. Figures 7 through 9 show the transmitter unit and Figures 10 and 11 show the receiver unit.

A 12-1/2 inch #18 copper wire may be used as an antenna on both

units; this is approximately a quarter wavelength at 432.9 MHz. This will give the maximum effective separation range for the system.

The file "MbxDet.zip" is available on the *Nuts & Volts* website (www.nutsvolts.com) and contains data sheets on the ICs, 432.9



PARTS LIST

(using NE567 tone detector)

All parts are available from Digi-Key unless otherwise noted. Also note that prices are subject to change without notice.

RESISTORS

- ☐ 2x 2.2K
- ☐ 4x 10K
- ☐ 3x 100K
- ☐ 3x 1M
- ☐ 1x 10M
- ☐ 1x 25K Pot

CAPACITORS

- ☐ 1x .022 µF
- ☐ 4x .22 µF
- ☐ 1x 2.2 µF
- ☐ 1x 1 µF
- ☐ 1x 47 µF
- ☐ 1x 100 µF

SEMICONDUCTORS

- ☐ 1x 567 Tone Decoder
- ☐ 1x CD4001 Quad 2in NOR
- ☐ 1x 555 Timer
- ☐ 1x CD4013 Dual Flip-Flop
- ☐ 2x 2N4403 PNP Transistor
- ☐ 1x 78L05 Five-volt Regulator
- ☐ 1x Red LED
- ☐ 1x Green LED

MISCELLANEOUS

- ☐ 1x Push Button Switch — Normally Closed
- ☐ 1x Reed Switch Magnetically Operated
- ☐ 1x Magnet
- ☐ 2x 14 Pin IC Socket
- ☐ 5x 8 Pin IC Socket
- ☐ 1x 2.5 mm Power Plug Male
- ☐ 1x 2.5 mm Power Plug Female
- ☐ 2x 3.34" x 2.2" x 1.38" Plastic Box
- ☐ 1x 5V Sonalert (optional)
- ☐ 1x 4.5" x 6.5" Vector Board
- ☐ 5x #4-40 Screw
- ☐ 10x #4-40 Nuts
- ☐ 1x 6-32 Screw
- ☐ 2x 6-32 Nuts
- ☐ 1x TWS434A 433.92 MHz RF Xmtr Module
- ☐ 1x RWS434 433.92 MHz RF Rcvr Module
- ☐ 1x 9V Battery Snap Connector

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AUTHOR BIO

■ Charles Irwin is a retired engineer and has worked for ITT Worldcommunications, AT&T, and Western Union over a period of 30 years. He holds an Extra Class Ham Radio License (NO2K) and has been licensed since 1974, receiving his first Amateur Radio License from the German Bundespost (DJ0HZ). Charles has been home-brewing electronic projects since he was 12 years old. He may be contacted at chuckirwin43@netzero.net

MHz transmitter and receiver modules, and Hammond plastic boxes. I have also included a Microsoft Excel spreadsheet for calculating parameters of the 567 tone decoder.

Also included in the zip file are printed

circuit board layouts for those who wish to make PCBs for this project. Both the foil side and parts side are shown. For photo-resist methods, the foil side layouts may be printed, but they need to be printed at the original DPI (dots/inch). A program I use for this is called Irfanview.exe and is available free from www.irfanview.com. This method of printing, unfortunately, only seems to work on PCs running XP software.

All parts for the system are available online at www.rentron.com and www.digikey.com except for the nine-volt battery connector which you can pick up from RadioShack.

I have been using the system for several months now and it really has made my life a little easier! Hopefully, it will do the same for you. **NV**

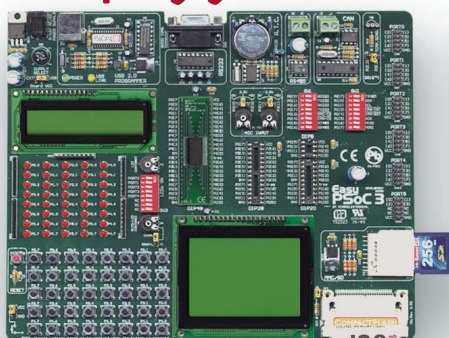
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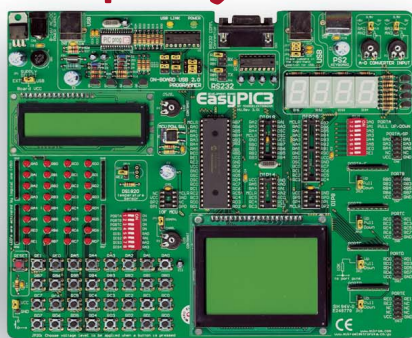
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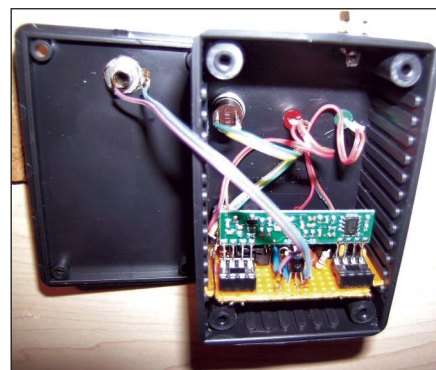
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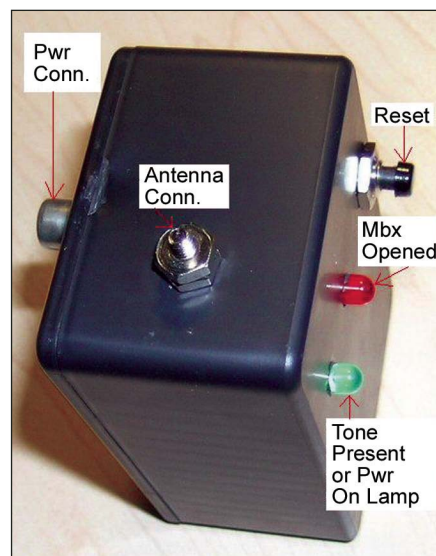
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■ FIGURE 10



■ FIGURE 11



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Requires 9VDC wall adaptor Uameco #252751 \$10.95.



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KC-5411 \$11.75 + post & packing

Most audiophiles know that loudspeaker enclosures have a natural frequency rolloff which is inherent in their design. The Bass Extender kit boosts the level of the bass to counteract the natural rolloff of the enclosure, producing rich, natural bass. It gives an extra octave of response, and is sure to please even the most avid audiophiles.

• Kit supplied with PCB, and all electronic components.



Starship Enterprise Door Sound Simulator

KC-5423 \$23.25 + post & packing

Emulate the unique sound made when the cabin doors on the Starship Enterprise open and close. It can be triggered by switch contacts, which means you can use a reed magnet switch, IR beam or PIR detector. Kit includes a machined, silkscreened, and pre-drilled case, circuit board, speaker and all electronic components with clear English instructions.

• Power: 9-12VDC.

NEW FOR '06

For all you Trekkie fans...



Voltage Monitor Kit

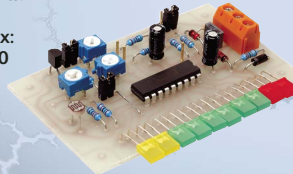
KC-5424 \$11.75 + post and packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features a 10 LED bargraph that lights the LEDs in response to the measured voltage, preset 9-16V, 0-5V or 0-1V ranges complete with a fast response time, high input impedance and auto dimming for night time driving.

Kit includes PCB with overlay, LED bargraph and all electronic components.

• 12VDC

• Recommended box: UB5 HB-6015 \$1.40



NEW FOR '06

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KC-5419 \$55.25 + post & packing

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Kit includes PCB, case and all electronic components with clear English instructions.

NEW FOR '06



Battery Zapper MkII

KC-5427 \$58.00 + post & packing

NEW FOR '06

The circuit produces short bursts of high level energy to reverse the damaging sulphation effect in wet lead acid cell batteries. This improved unit features a battery health checker with LED indicator, circuit protection against badly sulphated batteries, test points for a DMM and connection for a battery charger. Kit includes a machined, silkscreened, and pre-drilled case, circuit board, alligator clips, all electronic components with clear English instructions. Suitable for 6, 12, and 24V batteries.



Battery Zapper Add-On Kit

KC-5428 \$35.00 + post & packing

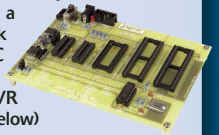
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AVR Adaptor Board

KC-5421 \$20.50 + post & packing

NEW FOR '06

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KC-5340 \$28.50 + post & packing

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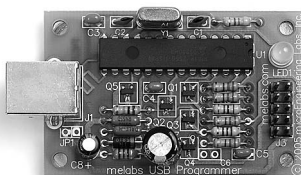
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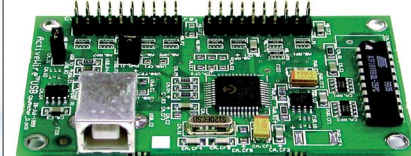
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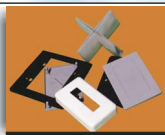
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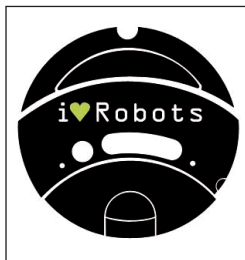
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SKIN THAT SUCKER



The "iRobot I Love Robots Skin" for an iRobot Roomba Discovery. Photo courtesy of iRobot Corp.

Just when you thought that it was a silly idea to plaster decals and stickers all over your Roomba, iRobot has introduced an innovative way to personalize your robot floor vac — iRobot skins.

A new April addition to the iRobot Store, these glossy vinyl iRobot skins — called Skinit — range from sports and college themes to a list of photorealistic skins that will catch your eye as Roomba cleans your floor (e.g., eye, pizza, and quarter skins). Best of all, Skinit isn't restricted to the supplied iRobot themes. You can roll your own.

Just snap your own digital photograph, upload it to the iRobot Skinit server, and iRobot will adapt your work of art to your Roomba or Scooba.

All of this fancy art doesn't come cheap, however. A skin — pictured here — "I Love Robots" costs \$19.98. Plus there is an additional charge of \$4.95 for postage and handling. Luckily, you don't have to handle your new skin with care — they are removable.

You can order iRobot skins from Skinit at www.irobotskins.com

FREE STUFF

Have you ever been frustrated with wanting to build a great widget only to give up because you can't find the right electronic part? Well, so did Limor Fried. That is until she organized a comprehensive list of sources for free electronics.

Able to sling a soldering iron with the best of 'em, Fried got fed up with part obsolescence, high priced ICs, and difficulty in locating a unique analog chip, so she created the definitive list for procuring free electronic components.

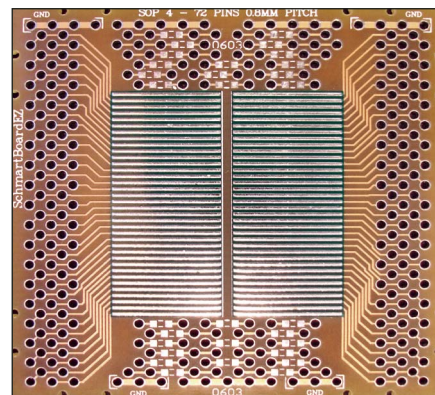
Need a PIC, Maxim serial line driver, or a ZigBee thingie? Fried can show you how you can request a "sample"

IC that won't cost you a thing or at least it won't cost you an arm and a leg.

After you've learned how to procure electronic components from Fried, be sure and nose around the rest of her website. Inside you will find some great circuits, wonderful kits, and an encyclopedia's worth of knowledge — all for free.

You can become enlightened by Limor Fried at www.ladyada.net and can see her list of freebies at www.ladyada.net/resources/procurement.html

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The Package. Photo courtesy of SchmartBoard.

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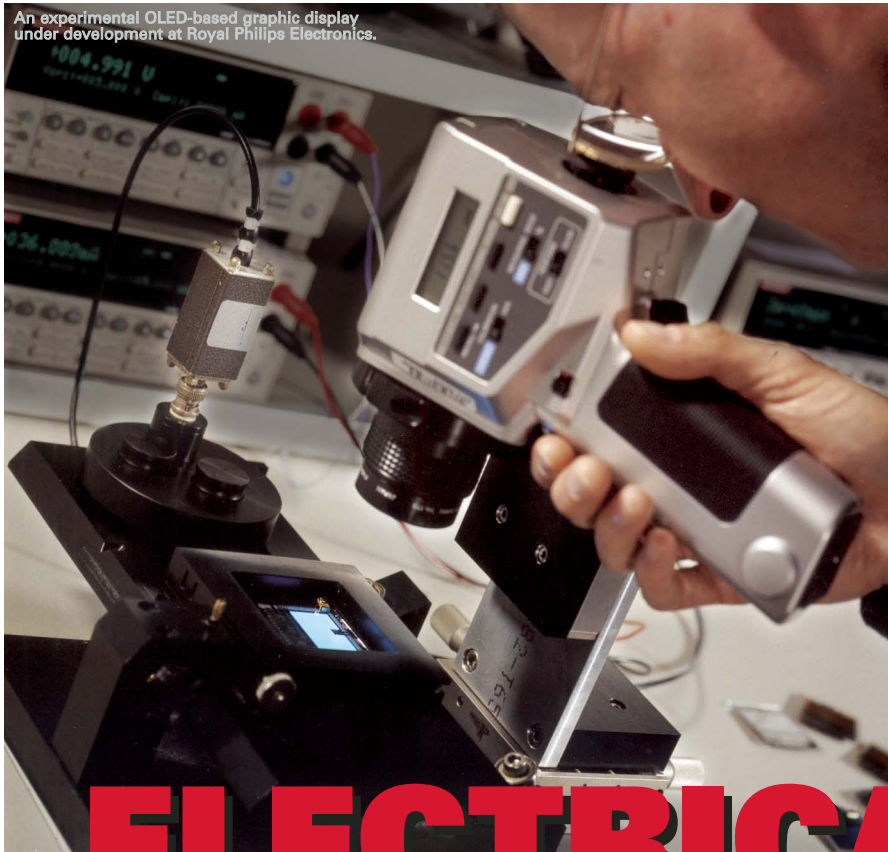
In a nutshell, SchmartBoard's "EZ" technology enables anyone to solder surface-mount components to PCBs ... by hand. While the SchmartBoard product has been available as a line of prototyping boards (e.g., in SO, QFP, PLCC, and BGA packages) since 2003, early this spring the SchmartBoard|ez technology was opened to independent licensing.

Now you can add a "EZ" SMT solder pad to any mass-manufactured PCB. Just think, your company could add an "EZ" pad to an experimenter's board or incorporate an "EZ" pad into a new circuit design reference board prior to the delivery of the ICs. Then new ICs could be tested and evaluated on these "EZ" PCBs without committing to a large manufacturing run.

Visit www.schmartboard.com for further info on the SchmartBoard. **NV**

New Electronics With

An experimental OLED-based graphic display under development at Royal Philips Electronics.



Since the early years of last century, plastics have transformed our lives in numerous ways. Our modern lifestyle would be unthinkable without heavy use of all kinds of different plastics. While plastics have a variety of useful properties, electrical conduction was not counted as one of them. That was until 1986 when a conducting form of polyacetylene — a so-called conjugated polymer — was discovered.

ELECTRICALLY CONDUCTING POLYMERS

◆ by Faiz Rahman

Several other conducting polymers were found in the following years. The common factor that causes conductivity in all these materials is the particular form of their molecular structure. Polymers consist of long chains of atoms connected to each other by single, double, or triple bonds. Organic polymers — which include plastics — consist of chains of carbon atoms with other atoms connected to the central polymer backbone.

In conjugated polymers, carbon atoms are alternately connected to each other with single and double bonds. This type of bonding is called sp^2 bonding by

chemists and is also found in graphite — a well known electrical conductor. The reason graphite and conjugated polymers conduct electricity is because an alternating arrangement of carbon-carbon bonds causes one electron per carbon atom to be very weakly bonded to the polymer chain. All such electrons are able to roam around freely in one (polymers) or two (graphite) dimensions and are called itinerant electrons. This then causes end-to-end conduction in electronic polymers and graphite, as seen in Figure 1.

However, because any bulk sample of a conjugated polymer consists

of chains only a few microns long that don't span its entire length, such samples don't show strong signs of electrical conductivity. Bulk electrical conduction is seen, however, when these polymers are doped with electron or hole donating agents. The excess carriers produced this way can jump from chain to chain producing sample-wide electrical conductivity.

Like all polymers, conducting polymers, too, can be easily processed into various shapes. A large application area is in coatings for corrosion prevention of ferrous metals, electrostatic discharge prevention for

sensitive electronic components, and electromagnetic shielding for electromagnetic equipment.

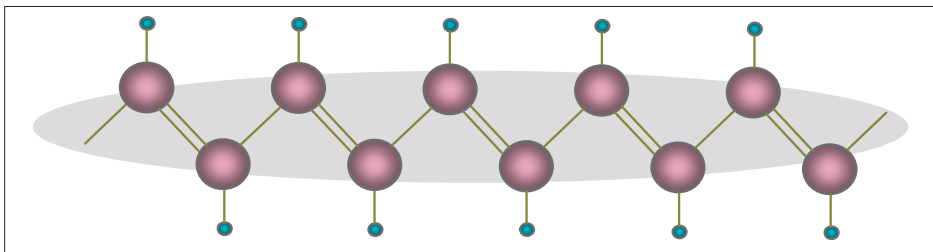
For these applications, polymers are dissolved or dispersed in various liquids and applied to metallic and plastic surfaces by dip coating, roller coating, or spraying. After a short drying step in an infrared oven, the applied polymer coatings reach their optimum conductivity values and become functional. Several companies have begun to market specially developed formulations for such applications.

Passive components like resistors, capacitors, and fuses have also been developed with conducting polymers. Miniature trimmer resistors are now available that employ plastic resistive elements contacted by a metallic wiper. These components show a superior temperature coefficient of resistance and lower noise characteristics than their carbon and cermet counterparts. Similarly, capacitors with one electrode made from a conducting plastic, such as polythiophene, exhibit longer life and reduced Equivalent Series Resistance (ESR).

Such capacitors are proving to be a superior alternative to conventional aluminium electrolytic types. When conducting polymers are heated to temperatures above 250° C, their electrical properties degrade rapidly and they stop conducting. This fact has been made use of in making slow blow fuses with conducting forms of polyaniline. These are ideal for protecting devices like electric motors and high-brightness solid-state lighting units.

Polymers have also found their way in batteries, with lithium polymer cells being their prime example. Replacing metallic electrodes with conducting polymers results in batteries that are lighter, have higher capacity, and are more resistant to harsh environments. For the same reasons, these materials are also being investigated for use in fuel cells.

Passives are, however, not the only components that could make use of conducting polymers in novel ways. The conductivity of these materials could be tailored to lie almost anywhere from being metallic through semiconducting behavior to insulating.



This capability opens up many possible applications where polymers, such as polyaniline, could be usefully employed. Indeed, researchers around the world have come up with many devices made from conducting polymers. These include diodes, transistors, light-emitting diodes, photodiodes, solar cells, chemical sensors, batteries, and dot-matrix displays. Whereas polymer-based electronics will not replace silicon as the semiconductor of choice because of the low speed of electrons and holes in these organic materials, some polymer devices have unique functionalities and these devices are emerging as the main applications of conducting polymers in electronics.

Polymer light emitters — also called Organic Light-Emitting Diodes (OLEDs) — are, perhaps, the most prominent of all such devices. These are made by coating glass or plastic sheets with various charge conducting and light-emitting material layers, such as polyaniline and poly paravinylene. The manufacturing process is much simpler and far less labor- and capital-intensive than that for ordinary LEDs. As a result, OLEDs are a potentially cheaper alternative to their more established cousins. Unfortunately, their electricity-to-light conversion efficiency is still quite low and their operating lifetimes also leave much to be desired.

Researchers are working on optimizing these devices and they should appear in several products by the beginning of 2007. One of these will be full color, large format flat panel displays, currently dominated by plasma and LCD panels. OLED-based flat panel displays — now under intensive development by companies like Philips — promise to be cheaper, lighter, less power-hungry, and capable of producing all-angle viewable images with highly vibrant colors.

The first such products are going to be OLED graphic displays for handheld gadgets like cell phones,

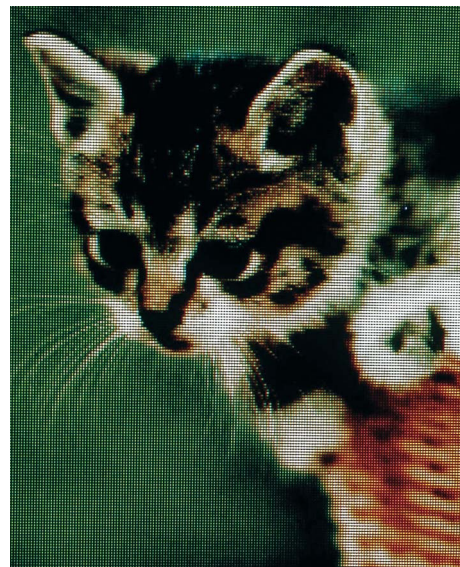
◆ **FIGURE 1. A segment of a polyacetylene chain showing alternating single and double bonds between carbon atoms (red spheres), lighter hydrogen atoms (green spheres), and a grey cloud indicating the presence of free electrons on the polymer backbone.**

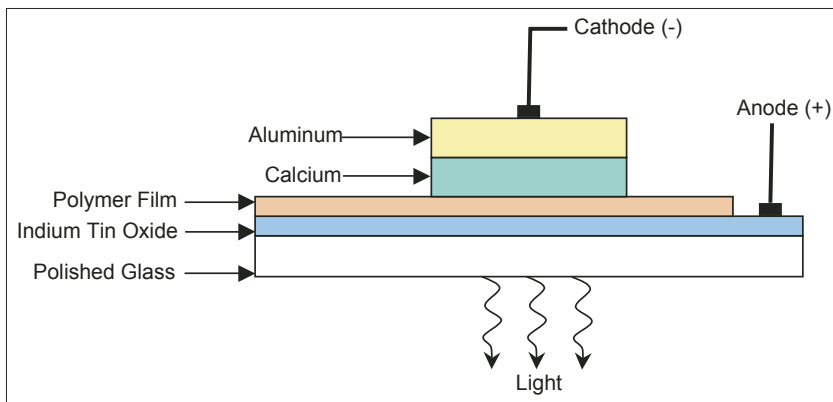
personal digital assistants, and electronic games. A close-up screen shot from a display recently developed at Philips is shown in Figure 2.

Apart from their uses in monochrome and full-color displays, OLEDs have also been investigated for making large area light emitters for space lighting. This is an area where conventional LEDs have not succeeded so far due to their directional emission characteristics and relatively high cost per unit. The fabrication of OLEDs relies on depositing polymer materials on rigid or flexible substrates like glass or plastic.

Various techniques have been developed to coat substrates with active polymer materials and deposit contact metals for making functional devices. One approach to building light-emitting diodes from organic materials is to sandwich them between a glass substrate coated with a transparent conducting

◆ **FIGURE 2. A close-up screen shot of an OLED flat panel display.**





◆ **FIGURE 3. Schematic diagram of an organic light-emitting diode showing its layer structure.**

up the possibility of extended area luminaries which may well make incandescent light bulbs obsolete in the not too distant future.

A related use of these materials is in devices that do the opposite and convert light into electric current. It is possible to make photodiodes from polythiophene and other polymers. Just as plastic-based light sources for space lighting are possible by extended sheet processing techniques, it is possible to make large area photovoltaic converters or solar cells.

layer (e.g., Indium Tin Oxide (ITO)) and a low work function metal like calcium, which is capable of emitting electrons into the polymer. When such a device is biased, as shown in Figure 3, holes from the polymer combine with electrons injected by the calcium electrode and light is released. There are several possible variations on this structure designed to increase the efficiency and lifetime of these devices.

Depending on the detailed structure of the polymer used, OLEDs can emit any color in the range from infrared to blue, so it is quite possible to build full-color displays from these devices. The revolutionary advantage offered by polymeric light-emitting materials is that the technique described above could be applied to continuous sheets, thus, coating very large area substrates, such as plastic sheets. This opens

Although the efficiency of polymer solar cells is less than half that of their silicon and gallium arsenide counterparts, making them cheaply in sheet form could result in very economical solar energy converters. When this becomes a reality in a few years, then plentiful solar energy will be much widely tapped as a natural resource than is the case at present.

Another application of conducting polymers where their properties really make a difference is in chemical sensors. Being composed of long, flexible chains of light atoms with plenty of empty inter-chain space, these materials can readily absorb gases and liquids. Such absorption, however, brings about marked changes in the polymer's physical properties — in particular, the electrical conductivity is altered quite strongly. This could become the basis of chemical sensing and various companies have developed biomaterial and hazardous substance detectors by combining polyaniline and polythiophene with appropriate electronic circuitry. Light-emitting polymers have also been used in this role by taking advantage of the fact that certain molecules, when bound to the polymer chains, alter the intensity and spectrum of light emitted by polymers such as poly fluorenes.

Detection of biologically active chemical species through such electro-biofluorescence is being vigorously investigated. The high sensitivity and robust nature of polymeric sensors is resulting in increasing use of these devices in fields ranging from environmental protection and forensics to medical research and industrial process monitoring.

Perhaps the most exotic use of conducting polymers is going to be in flexible integrated circuits. Because common semiconductor devices — such as diodes and transistors, as well as passive components and conducting tracks — could be made from these bendable materials, it is entirely possible to build a complete working integrated circuit on a flexible plastic backing sheet. Such ICs have indeed been built and successfully tested. The principal advantage of flexible integrated circuits will be in making inexpensive electronics for security tagging, personal identification, and electronic product labelling.

Conducting plastics are causing great excitement in industrial and academic research labs. Their combination of useful properties means that many existing semiconductor applications will be recast with polymers and several entirely new ones will be developed in the near future. Only the coming years will tell us how these novel materials will impact our lives and what new devices they will make possible. **NV**

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A Pocket PC running on a robot.



Programming the Pocket PC

by Walter O. Krawec

A typical Pocket PC sports a 200 MHz CPU along with 64 MB of RAM and a 65,000 color LCD — all within a case designed to fit in the palm of your hand. Additionally, these devices usually run a version of Windows CE as their operating system, making it easy for us to develop applications for them, given the right tools.



A sample development environment.

What follows is a brief introduction to the free “eMbedded Visual Tools SDK” (no that ‘M’ is not a typo), along with some information on how to perform certain tasks on your PPC, like accessing the serial port. Please keep in mind that this is not a tutorial on the C++ language, so it is assumed that you have at least some knowledge of C/C++, and also knowledge of basic Windows programming would probably be helpful.

What You’ll Need

Really, all you’ll need to begin developing applications for the Pocket PC is the free eMbedded Visual Tools SDK. This includes not only a compiler and IDE, but also an emulator so that even if you don’t own a “real”

PPC, you can still test and debug your programs all from your desktop. If you’re looking to buy a PPC, then you can usually find a new one for \$200-\$500 through your usual retail stores. You could also probably find a decent used one for even cheaper if you look around (eBay, etc.).

eMbedded Visual Tools

Before writing software for a Pocket PC, we’ll need a compiler of some sort that is capable of creating executables that the processor inside a PPC can understand. Microsoft has released an entire SDK just for this purpose known as “eMbedded Visual Tools” (this is a completely free download — you can find the URL in the Web Links sidebar). Once installed,

you will have access to a C++ and Visual Basic compiler, along with a powerful emulator. Of course, with this also comes some documentation and several example programs — everything you need to begin developing applications for a PPC!

As mentioned earlier, the eMbedded Visual Tools SDK includes two different compilers: C++ and Visual Basic. You can, of course, use either one, however, since I have no knowledge of VB programming, this article will focus on the C++ side of things. If you want to use the VB compiler, that’s great. However, I doubt that this article will aid you much on your quest. I suggest if VB is your choice, you simply skip ahead a few pages to the next great article in this magazine (or skip back a few pages if

this article was stuck in at the end).

So now to talk a little about the compiler. After installing the SDK, you will have access to the complete Visual C++ 3.0 IDE. While it can't compare to the latest version of Visual Studio, I can still say that this is a nice IDE to work with. It will keep all of your source files organized into projects and, using its "IntelliSense," it is able to help you out a lot during the development of a program. If you've used a Visual Studio product, you know what I mean. And if you haven't, you'll see when you actually start writing programs.

The other great feature of the SDK is, of course, the emulator. Not only does this allow you to easily test and debug your programs, but it also allows you to begin programming PPC applications without even owning an actual device! On top of all this, the emulator is designed to work seamlessly with the VC++ IDE so that when you hit the "Compile" button, the program will automatically be transferred to the emulator and run.

One last point to mention before continuing is the availability of a powerful, real-time debugger. This means that even while your program is being run on the emulator, you're able to inspect variables via the Watch Table, step through your code one line at a time, and even tell the debugger to "watch" a certain variable and alert you whenever it changed. Of course, I'll discuss this in greater detail later, so now let's start on our first PPC program.

Hello World!

Our first PPC program could quite possibly be the easiest you have ever created, as you really aren't going to be doing any coding. If you've ever programmed in C++ to create a standard Windows application, you'll know that it takes a lot of code to simply set up the window. However, in Visual C++, this process is automated for you (if you want it to be, of course) when you create a new project (a project in Visual C++ is simply a large collection of source files).

So, to start, first open up

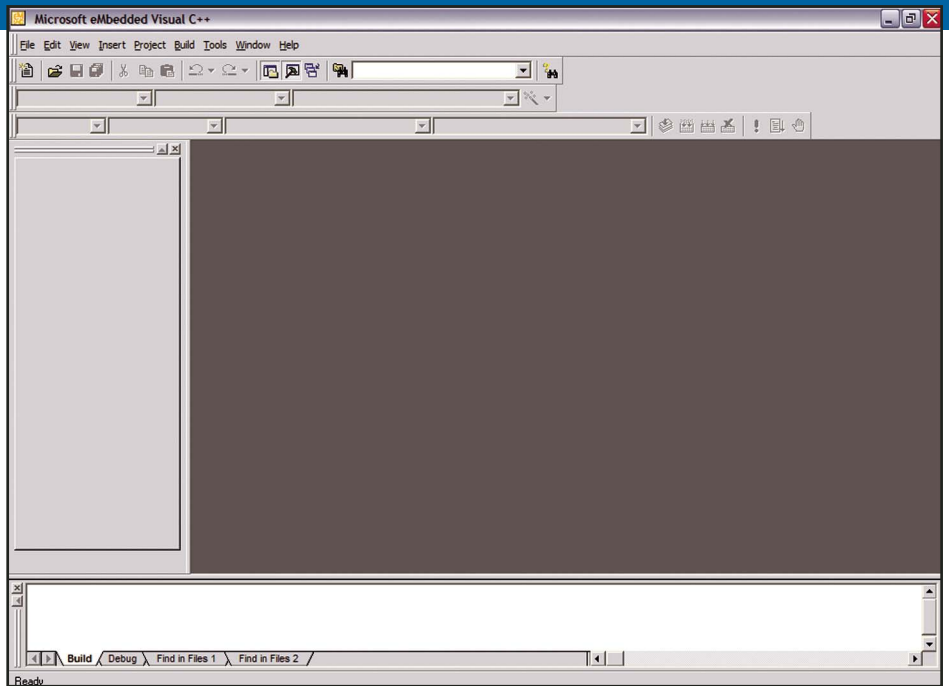


FIGURE 1. eMbedded Visual C++ IDE.

eMbedded Visual C++ (you did download and install the SDK already, right?). You will be presented with something that looks like Figure 1. Now create a new project by selecting "New" from the file menu. You will then be presented with several choices, as shown in Figure 2. To create our "Hello World!" program, we want a "WCE Pocket PC 2002 Application" (usually the first choice). Make sure that's selected, give your project a name in the appropriate edit box, and press the "OK" button.

A new set of options will be presented to you. Usually, you would want "A simple Windows CE Program," however, for this example we're going to create "A typical 'Hello World' application." Select that and then press the "Finish" button. Press "OK" one more time at the confirmation box, and the App Wizard will create a new project and add all the source code needed to print out the text "Hello World!" on the PPC's screen.

Let's take a look at the source code first. Go to the "FileView" menu (that's a tab in the lower left corner of the screen), double-click the "Source Files" folder, and then open up the

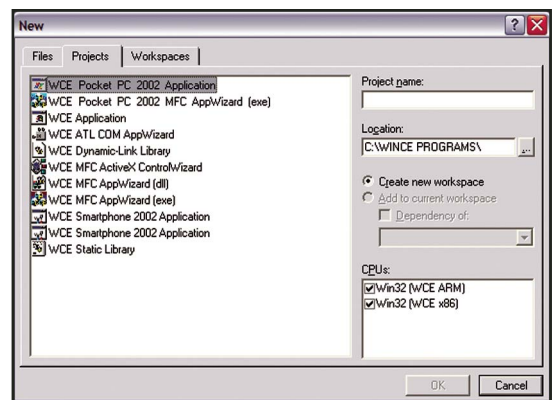


FIGURE 2. Creating a new project.

correct .cpp file (it should have the same name as your project). You can see that the App Wizard did a lot of the busy work for us so that we can jump straight into the more interesting parts.

This article isn't meant to be a detailed tutorial on C++ or general Windows programming, but rather an introduction to the tools required for programming a PPC, so I'm not going to go through this file in great detail. However, it is important to make note of a few things ...

WinMain() — The First Thing Ever Run

If you take a look at Listing 1, you'll see a copy of the **WinMain()** function. This is the main entry point into your program (much like the standard **main()** in C). Nothing of great

LISTING 1. The WinMain() function.

```
int WINAPI WinMain(    HINSTANCE hInstance,
                      HINSTANCE hPrevInstance,
                      LPCTSTR lpCmdLine,
                      int nCmdShow)
{
    MSG msg;
    HACCEL hAccelTable;

    // Perform application initialization:
    if (!InitInstance (hInstance, nCmdShow))
    {
        return FALSE;
    }

    hAccelTable = LoadAccelerators(hInstance, (LPCTSTR)IDC_TEST2);

    // Main message loop:
    while (GetMessage(&msg, NULL, 0, 0))
    {
        if (!TranslateAccelerator(msg.hwnd, hAccelTable, &msg))
        {
            TranslateMessage(&msg);
            DispatchMessage(&msg);
        }
    }

    return msg.wParam;
}
```

LISTING 2. The WndProc() (message handler) function.

```
LRESULT CALLBACK WndProc(HWND hWnd, UINT message, WPARAM wParam, LPARAM lParam)
{
    HDC hdc;
    int wmId, wmEvent;
    PAINTSTRUCT ps;
    TCHAR szHello[MAX_LOADSTRING];

    switch (message)
    {
        case WM_COMMAND:
            wmId    = LOWORD(wParam);
            wmEvent = HIWORD(wParam);
            // Parse the menu selections:
            // ...
            break;
        case WM_CREATE:
            g_hwndCB = CreateRpCommandBar(hWnd);
            // Initialize the shell activate info structure
            memset (&s_sai, 0, sizeof (s_sai));
            s_sai.cbSize = sizeof (s_sai);
            break;
        case WM_PAINT:
            RECT rt;
            hdc = BeginPaint(hWnd, &ps);
            GetClientRect(hWnd, &rt);
            LoadString(g_hInst, IDS_HELLO, szHello, MAX_LOADSTRING);
            DrawText(hdc, szHello, _tcslen(szHello), &rt,
                    DT_SINGLELINE | DT_VCENTER | DT_CENTER);
            EndPaint(hWnd, &ps);
            break;
        case WM_DESTROY:
            CommandBar_Destroy(g_hwndCB);
            PostQuitMessage(0);
            break;
        case WM_ACTIVATE:
            // Notify shell of our activate message
            SHHandleWMActivate(hWnd, wParam, lParam, &s_sai,
                               FALSE);
            break;
    }
}
```

interest happens in here — except for the initialization of the main window through a call to **InitInstance()**. You can take a look at that function if you'd like, but how to set up a window is way beyond the scope of this article. The thing to keep in mind here is that the **WinMain()** function is the very first thing that's run, so if you have anything to set up or initialize, this is the place to do it.

WndProc() — The Message Handler

In this example, our message handler is defined as **WndProc()**, which you should be able to find within your source file, or by simply looking at Listing 2. This is the place where most IO calls will be sent or any other “message” that the OS wishes to send us. So, whenever a user taps the screen or presses a button, for example, the OS will send out a message which will be picked up by **WndProc()** — our message handler. In there, you'll see that we have a simple **switch()** statement to check to see what message was sent (obviously, we don't check for every message right now!). You should take note of the **WM_PAINT** message which tells our program to re-draw our window and, in our example, print out the text “Hello World.”

Compile and Run

Let's actually compile and run this program! Simply select “Execute” from the “Build” menu. This will automatically build the program and send it off to the emulator for testing.

So, assuming you haven't modified the source code in such a way as to create errors, your program should compile and run without any problems.

After it compiles, you should see the emulator pop up (it takes a while to load the first time it's run, however, after that it's faster ... just keep it running in the background). Give it just a few more seconds and you'll see your “Hello World!” program running in all its glory!

Debugging

Now that we actually have a working program, we can play around with the debugger. While using the emulator to test your applications, you have access to such features as breakpoints, the watch table, and the ability to single-step through your program (such things are, of course, unavailable to you if you're running your program on actual hardware). No doubt you already know what these things do, so I'm not going to spend much time talking about them, however, I am going to explain how to access these features.

Breakpoints are probably the easiest debugging feature to use and all they do is stop your program's execution, returning control to the IDE wherever you place them. When this happens, you'll be able to analyze variable contents, use the watch table, etc., which I'll talk about shortly. To set a breakpoint, simply right-click the line you wish to stop at and select "Insert/Remove Breakpoint." Now, whenever you run your program, as soon as it reaches this position, it will break out allowing you to access several of the other debugging features.

You can also set different types of breakpoints such as one that will stop the program whenever a certain variable is altered in anyway. Explore the breakpoint menu (press CTRL-B to access this menu) for details.

The Watch Table allows you to view the contents of any variable (that's in scope, of course) while the program is paused (using a breakpoint, for example). To add a variable to the Watch Table, simply type the variable's name into the Name column of the Watch Table after which its value will automatically be printed next to it (Figure 3).

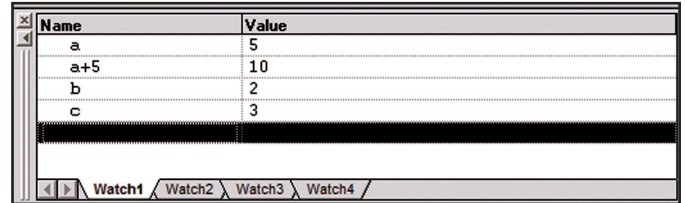
Better still is the ability to alter the value by simply modifying the contents of the "Value" column. Another feature available here is the ability to view the contents of a variable quickly by simply hovering over the text (that way you don't have to add it to the Watch Table if you don't want to).

Listing 2 continued ...

```
case WM_SETTINGCHANGE:
    SHHandleWMSettingChange(hWnd, wParam, lParam, &s_sai);
break;
default:
    return DefWindowProc(hWnd, message, wParam, lParam);
}
return 0;
}
```

You can also use the "Quick Watch Table" if you only want to look at and/or modify one variable.

Another feature is the ability to single-step through your program. With the program paused, simply use the "Step Over," "Step Into," and "Step Out" buttons. Pressing the Step Over button will cause your program to execute the next line and pause again afterwards. "Step Into" will also run



Name	Value
a	5
a+5	10
b	2
c	3

FIGURE 3. The Watch Table.

your program is trying to do, thereby greatly helping you in solving whatever problems you might encounter while working with the PPC.

The Serial Port

So, if we ever want our PPC to communicate with other devices (such as a robot or your PC), we'll need to access a communications port of some sort — the first of which is the serial port.

Just about all PPCs have a serial port of some sort which is used mostly for keeping data synchronized between it and the user's PC. Because the code for accessing this system can be slightly overwhelming, I created a simple, easy-to-use class that you can download from my website (a class is an object in C++ which, among other things, can contain functions and variables). I won't go over how this class works, but I'll explain how to use it. You can use the following instructions to

"A typical Pocket PC sports a 200 MHz CPU along with 64 MB of RAM and a 65,000 color LCD — all within a case designed to fit in the palm of your hand."

only one line at a time, however, it will pause inside of another function if needed. "Step Out" will bring you out of the current function and pause after the line in which it was called.

Of course, during all of this, you can continue to use the Watch Table to monitor your variables and see what

LISTING 3

```
SerialPort com1;
com1.InitSerialPort( SetupPort( 9600, 8, NOPARITY, ONESTOPBIT ) );
```

LISTING 4

```
char c;
if( com1.ReadByte( &c ) ) {
    // we've received a byte and the value is stored in "c"
}
else {
    // nobody's talking to us right now :(
}
```


access the features of other classes I have available for download, as well.

After downloading the files (SerialPort.cpp and SerialPort.h), include both in your project and add a **#include "SerialPort.h"** command to the top of your main program file. This will give you access to the contents of the SerialPort class. Now, to actually use this class in your WinMain function, add the code shown in Listing 3. That will open the serial port at 9600

baud, no parity, etc. (take a look at SerialPort.h for more details). I called our SerialPort object "com1" for no significant reason — you can call it whatever you like (for the most part).

To send a byte through the port, use the **SendByte** command like so:

```
com1.SendByte( BYTE_TO_SEND );
```

where "com1" is the name of the SerialPort object you created before,

and BYTE_TO_SEND is, of course, the byte you wish sent. Receiving is almost as simple (see Listing 4).

This is slightly more complicated due to the fact that the ReadByte function has to return two values: a boolean (which is true if data was sent and false otherwise) and the actual data that was sent. Don't worry about closing the com port when you're finished, as this is automatically done for you when the "com1" object goes out of scope (for example, when your application ends).

Conclusion

Take a look at the addresses in the Web Links sidebar for more information, including downloads for the visual tools, as well as the above mentioned SerialPort class. There's a lot this article didn't talk about, including creating custom GUIs, using WinSock for communicating over a LAN, and even more that the PPC is capable of. However, if you have any questions or comments, please feel free to email me. Have fun coding! **NV**

WEB LINKS

<http://msdn.microsoft.com/mobility/othertech/default.aspx>

Go here for information on "eMbedded Visual Tools."

<http://msdn.microsoft.com/mobility/downloads/sdks/default.aspx>

Follow the links here to find and download the free eMbedded Visual Tools SDK (I'd give you a direct link, however, the URL is long and seems to be continually changing ...)

www.geocities.com/waltsrobots/PPCArticle.html

Here, you will be able to download the SerialPort class.

<http://msdn.microsoft.com>
MS Developer Network. This has information on just about everything related to Windows programming.

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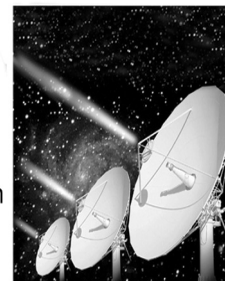
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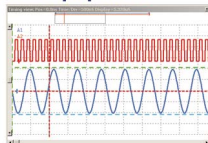
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Atlas on the launch pad.



Little Joe test rocket.



Atlas being raised onto the launch pad.

Spacecraft Films Reopens The New Frontier

In early 2006, Spacecraft Films released a six DVD set titled *Project Mercury: A New Frontier*, containing 24 hours of footage from America's pioneer space efforts. Coming at the height of the Cold War, this was America's first attempt to put a man into space — culminating, of course, in President Kennedy's famous challenge to land a man on the Moon within the same decade.

by Edward B. Driscoll, Jr.

“Today, after Kennedy's challenge was successfully — spectacularly — met, and Hollywood has thoroughly explored the rest of the universe in its *Star Trek* and *Star Wars* franchises, the original Mercury flights may seem — at first glance — somewhat antiquated by comparison.”





The astronauts' wives at the launch.



Cape Canaveral.



Custom painting logo on John Glenn's Mercury Capsule.

Today, after Kennedy's challenge was successfully — spectacularly — met, and Hollywood has thoroughly explored the rest of the universe in its *Star Trek* and *Star Wars* franchises, the original Mercury flights may seem — at first glance — somewhat antiquated by comparison. The equivalent of parking the original Wright flyer next to a B-2 bomber or Boeing 747. And Spacecraft Films' policy of providing uncut, largely unedited, but digitally cleaned-up footage highlights in detail just how innocent this early period of manned space exploration was.

But the reality was much different — Project Mercury came at a time when America seemed genuinely at risk of being beaten by the Soviet Union in what became known as the Space Race. The unmanned Sputnik began orbiting the Earth in 1957. The

heat was then on to see which nation would put a man into space first.

As the lengthy documentary that begins the first Mercury disc reminds us, it was only because of strict testing after a minor flaw in the last unmanned mission of Mercury that Alan Shepard's first flight was delayed. Unhappily for America, that meant that in April of 1961, the Soviets were able to launch Yuri Gagarin into space first, putting further pressure on Project Mercury and its astronauts.

Fortunately, they were more than up to the task — all of the astronauts involved in Project Mercury were originally crack test pilots, at President Eisenhower's insistence. As Tom Wolfe thoroughly documents in his seminal 1980 book — *The Right Stuff* — these were men who had backgrounds in engineering and were

superb pilots while on duty, and superb hellraisers off-duty.

The exception to the latter was John Glenn — “The Clean Marine” — as he was known to the other astronauts. Most Americans of the early 1960s knew little about the world of hotshot young pilots, and Glenn's persona was so powerful, that once the astronauts met the press, it instantly became the collective public character of all the astronauts.

But in reality, as Wolfe once told an interviewer, the other pilots actually had “a much wilder code of conduct than the astronauts were presumed to have observed. Drinking, wild driving, and displaying one's manliness towards ‘the cookies,’ as they say, were by no means out of bounds ... I think they more than likely said to themselves, ‘Gee, how can we keep the lid on this?’”

This is the very, very early days of NASA — the summer of 1959 — when a Mercury spacecraft is being transported — on the back of a pickup truck, cushioned by mattresses — from its hanger in Cape Canaveral to the launch pad for the first unmanned reentry test. Photo from the book *Apollo: The Race To The Moon*, by Charles Murray and Catherine Bly Cox.



DVDs Document Pioneering Technology

The Mercury flights were rather brief in comparison to the duration of the missions that American and Russian astronauts have since logged aboard orbiting space stations — Shepard's first suborbital flight lasted all of 15 minutes and 28 seconds. Glenn's three-orbit flight lasted slightly under five hours. And the last and longest Mercury launch — flown by Gordon Cooper — was 34 hours long.

But, as the DVDs recount, the brevity of these missions didn't make them any less dangerous. Virgil “Gus” Grissom's second suborbital flight ended with his capsule sinking into the Atlantic Ocean. While John Glenn's flight was orbiting the Earth, there was real fear within Mission



Enos the chimpanzee after his two orbit test flight.



Examining the model.



Glenn examines the suit.

Control that it would end in horror, as the status of his capsule's heat shield was unknown for much of the mission.

And *all* of this was brand new technology — the Atlas rocket used for Mercury flights had only been first launched in 1959. The smaller Redstone suborbital rocket actually had more experience, having been first launched in 1953.

In Charles Murray and Catherine Bly Cox's classic book *Apollo* (originally published in 1990, recently reissued), which focuses on the engineers who staffed Mission Control during NASA's golden era, there's a photo of the first Mercury capsule being delivered to Cape Canaveral on the back of a pickup truck. Similar shots in Spacecraft Films' Mercury collection also hint at how far and how fast NASA and its subcontracted industries progressed in the 1960s. But at the start of the decade, it was burly men building Mercury capsules in short-sleeve L.L. Bean camp shirts, not the white clean room jumpsuits and booties we'd come to associate with NASA.

Meet the Man Behind the Discs

Of course, Project Mercury is merely the latest in an extensive line-up of DVDs from the Spacecraft Films (www.spacecraftfilms.com), a North Carolina-based firm that documents all of the missions of NASA's halcyon days. The man behind them is Mark Gray, who grew up the son of a Huntsville-based NASA contractor. After over 20 years in the television industry, ending with a stint as a station manager, Gray says he was

"kind-of dissatisfied with what I was doing in the TV business. I didn't feel as though it was necessarily handing a lot back," and looked for a change.

The near-simultaneous birth of DVD, and advancement in film transferring technology in the second half of the 1990s helped him make up his mind. "I had always wanted to see this material," says Gray "and knew that if it were transferred to video today, it would look much better than the transfers from the 1970s. And you almost needed DVD to do this, because with the amount of stuff I wanted to provide, you would have to fast-forward and back-up and do all kinds of stuff to get to the areas in the presentation that you'd want, and it wouldn't have worked near as well on tape.

So I basically decided that this might be something that there would

be enough interest in, and I could create a business out of."

Tremendously Loyal Fans, but Not for All Tastes

The result for Gray has been a steady business with a group of tremendously loyal fans. "It's not a huge market, but it's a niche market that's been large enough that it's been good. It's enabled us to get through basically the major areas of space history, and now we're branching out into more. So I can't complain about that at all." Branching out includes a more terrestrially bound division Gray's launched called Aircraft Films.

Not everyone appreciates the Spacecraft Films style, which, admittedly, is fairly clinical, uncompromising, and unedited — especially compared with Hollywood's attempts

John Glenn and Scott Carpenter.



Alan Shepard doing some training.





Sigma 7 on the launch pad.



Glenn's Tickertape Parade.



Gordon Cooper suits up for the last Mercury flight.

in the 1990s at dramatizing NASA's halcyon days, both on the big screen (*Apollo 13*) and small (*From the Earth to the Moon*). There's also *For All Mankind* — a superb documentary released in 1989 to celebrate the 20th anniversary of the Moon landings by Texas-based documentarian named Al Reinert. It was built around the best moments in NASA's Apollo footage, and edited around an atmospheric Brian Eno score.

Gray is quick to point out the difference between those projects (which he admires, with reservations) and his. "We really don't make any apologies for what we're doing; we're not doing something that is mainstream. You have to really be into this

subject to want to see these the way that we present them — with as little filter as possible, exactly what happened in the record. And I learned very early on, from the feedback that I got from our sets, that there were a lot of people that really, really wanted that, and that this was what they were really looking for, which confirmed the idea I originally had for these discs."

But Gray says that some viewers "just couldn't handle" his approach. "I don't want to say 'it freaked them out,' but that's the best explanation I can give for it. Because they were very, very used to, I think, having everything packaged up the way that American television and movies do it, and honestly, there were some folks who, I guess, thought they wanted it the way we do it, but as it turns out, they didn't."

Which perhaps, ironically, mirrors one of the reasons given for the premature termination of the Apollo moon landings in 1972 — the American public found manned spaceflight boring and somewhat anticlimactic, once Neil and Buzz had set foot on the Moon and returned.

Watching the TV broadcasts amidst all of the other material assembled in *Spacecraft Films' Apollo* DVDs, I can sort of understand how they felt. In-between Apollo's spectacular launches and nail-biting splashdowns, the stately pacing of

Stanley Kubrick's *2001: A Space Odyssey* seems far more true-to-life than the whiz-bang videogame feel of *Star Wars*.

A Historian's Dream

All of the *Spacecraft Films* DVDs also provide a myriad of details of life back on Planet Earth in the 1960s and early 1970s, as well. In a way, they're a historian's dream — the swank and polished early JFK 1960s depicted in the Mercury discs looks nothing like how we envision the psychedelic final years of that decade.

Spacecraft Films' Apollo 13 disc, subtitled appropriately enough, "The Real Story," is, in particular, as much a unique look back at life on Planet Earth as it is a look back at the mission itself. The astronauts were understandably far more interested in saving their own skins than shooting movie footage, so the disc contains more images of NASA representatives and the media than there are of the mission after astronaut Jack Swigert reported "Okay, Houston, we've had a problem here."

But those images are quite interesting, not only because of what they show us about how the mission control teams dealt with the crisis, but also for what they tell us about American society in 1972.

Smoking was still commonplace and universally accepted. Even among astronauts, as original Mercury 7 astronaut and then-Director of Flight Crew Operations Deke Slayton (in a horrid striped forest green polyester suit and pastel striped tie) lit up a thin brown cigarillo during a press conference, and tamped the ashes into one of a series of heavy glass ashtrays that

Mercury-Atlas 1 test flight destroyed capsule.





Press conference for the Mercury 7 astronauts.



Recovering Sigma 7.



Redstone leaves the launch pad.

NASA had put out for their representatives when meeting the press. Other Spacecraft Films DVDs show men smoking pipes around in-construction Saturn Vs, which is something that would be unthinkable in today's world of equally sanitizing clean rooms and political correctness.

The press itself, in the Apollo 13 DVDs, is in sharp contrast to the way today's media conducts itself while interacting with the president or the military. Pre-Watergate 1970-era journalists didn't seem to be trying to play "gotcha" games with Slayton and other NASA representatives. And it's amusing to watch shots of them filing their stories via manual typewriters and telegraph machines.

There's also a classic "Right Stuff" moment, when a reporter asks Slayton, "Have you figured out yet what you think happened?"

Slayton replies, "I don't think there's any question that we have to understand this before we can probably commit too much further. It's the kind of a failure that can give you a pretty bad day if you don't have the LEM around." And even Deke smiles at how just how Test Pilot Cool the vapor trails of his lines are.

Relying on Astronauts' Input

Collating and restoring countless hours of NASA footage has been a challenge for Gray. To assist, he has consulted with many of the surviving members of the elite fraternity from NASA's golden years. "Oh yeah, I've talked to a number of the astronauts. We always send each crew a copy of the disc they're featured in, and they're always very appreciative. I've

had a lot of them say, 'You know, I've never seen most of the stuff that's in your DVD.'"

Gray says that he promised himself when he started Spacecraft Films, that the astronauts would never have to pay for a copy of their discs. "And I've had several who've wanted to order sets for their grandchildren, and I wouldn't let 'em [pay for it]. Luckily, they were all within reason, and I didn't go broke doing that! But it was nice; they felt that it was a way that their exploits were preserved for their children or grandchildren. And that's been nice, too."

Maintaining cordial relations with NASA's elite pays other dividends, as well for Gray. "If I'm working on their mission and I have a question about who shot what footage, I can call or email. I can ask, 'Say, what was the deal here? Were you shooting into a mirror, why is this shot reversed?'"

On the other hand, Gray notes that "you can't take people out of their time. I've had at least two moonwalkers who didn't have DVD players, and at least one who, not only didn't have a DVD player, but had problems hooking it up when he finally got one."

Which is kind of a sad prospect, as the nine living men who've walked on the moon age; they knew how to control a 364-tall Saturn V, but not a machine that plays a five and a quarter inch silver disc.

But for the rest of us, the reverse is true. And unless NASA or commercial entrepreneurs (see the March '06 issue of *Nuts & Volts*) get going in a hurry, Spacecraft Films' efforts may be the closest many of us will get to knowing what it feels like to be an astronaut. Fortunately, they're a great substitute while waiting to hit the new frontier ourselves. **NV**

Mercury control room during Glenn's flight.



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USB DEVICE CONTROL

by Alexander Enzmann

USB interfaces are now the dominant port available on PCs, with several available on nearly all machines. With the parallel port nearly gone and typically just a single serial (RS232) port available, simple ways to control devices through USB have become essential.

This article describes an inexpensive way to interact with devices using Microchip's PIC 18F2455 microcontroller. The total cost to get started with USB is under \$15, with about half of the cost associated with the microcontroller chip itself.

This is not intended to be a tutorial on the nitty-gritty details of USB — there are plenty of resources for that. The intent is to

provide enough hardware and software so that you can actually start building things, rather than spend weeks reading manuals. You will end up spending plenty of time learning USB — hopefully the code provided with this article will flatten out the learning curve a bit.

The PIC 18F2455 (and siblings 2550/4455/4550) has the basic hardware support for low- and full-speed USB (no high

speed). For most device control applications, this will be more than enough.

Alternatives

Alternatives such as USB to RS232 converters exist in both

IMPORTANT NOTE

All software and firmware files are available on the *Nuts & Volts* website at www.nutsvolts.com under the name "USB.zip."

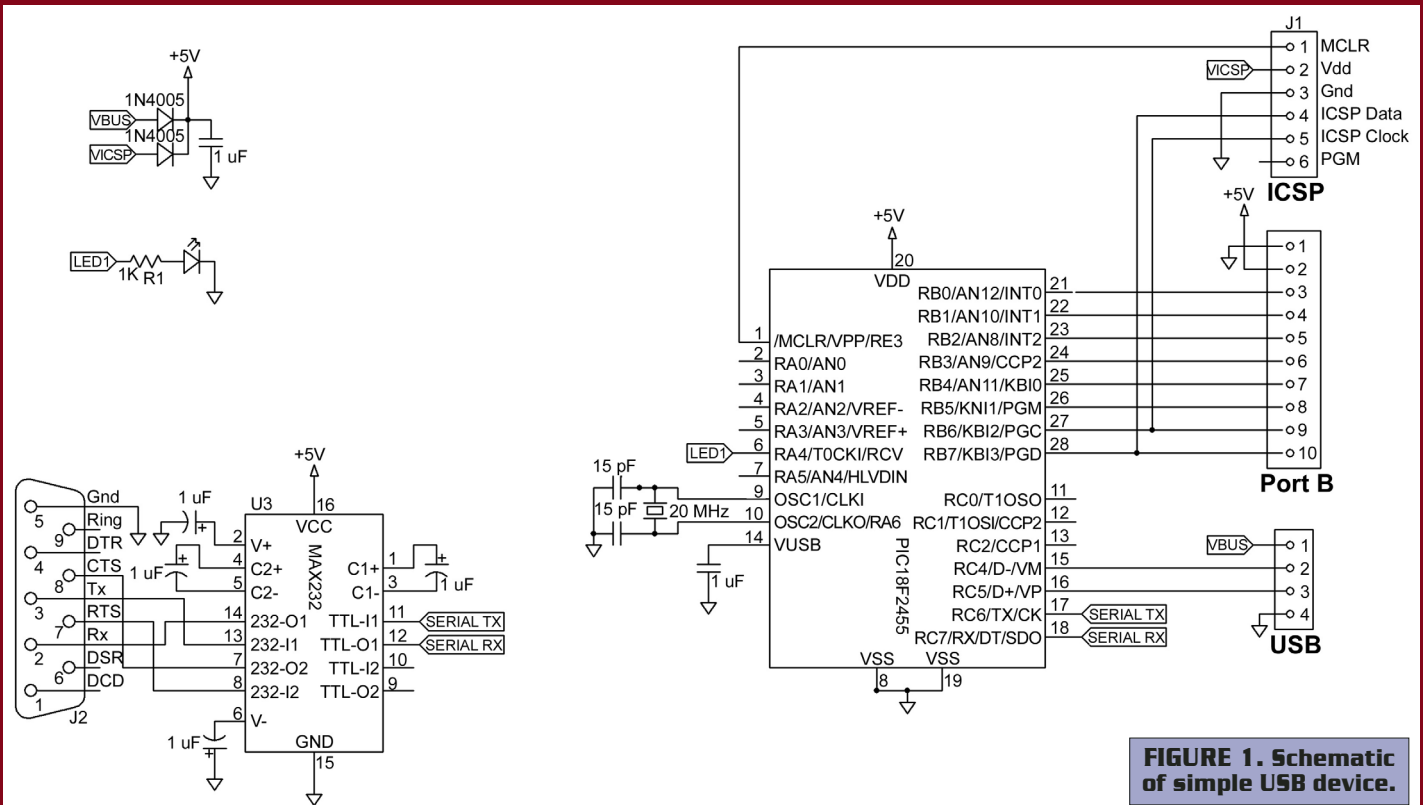


FIGURE 1. Schematic of simple USB device.

USB DEVICE CONTROL

TABLE 1. Parts list for basic device.

PART	QTY
■ Perfboard (RadioShack 276-150)	1
■ Microchip PIC 18F2455 I/SP	1
■ TI MAX232N	1
■ 20 MHz Xtal	1
■ 15 pF Cap	2
■ 1 µF Cap	5
■ 10 µF Cap	1
■ Six Pin 0.1" Header	1
■ USB-B PC Mount	1
■ DB9 Female Socket	1
■ 1N4001 Diode	2
■ 1K 1/8W Resistor	1
■ T 1-3/4 Red LED	1
■ 28 Pin IC Socket	1
■ 16 Pin IC Socket	1

chip and complete device form. While these can fill an immediate need to get something working, they do not get you to a real USB device

— you will not be getting into the mindset and process flow that is necessary to interact with USB.

A key difference is that when using USB, the host (PC) initiates all transfers of data — both to and from the device. You cannot treat it like a parallel or serial port where you blindly send bits.

A Basic USB Device

The first step will be getting the PC and PIC to talk to each other. A schematic of a simple USB device is shown in Figure 1. In addition to the PIC processor, it contains a MAX232 chip to support RS232 serial communications. This approach eases the transition to USB by allowing debugging in the traditional way — sending messages from the PIC to the PC

and watching them scroll by in HyperTerminal.

The serial connection is not essential to any part of the firmware. It is only used for debugging. Once you are comfortable that the USB framework is up and running correctly, the serial interface can be removed. You will find that you can just as easily send the debugging information through a USB report. A complete list of parts is given in Table 1.

This device demonstrates a significant

advantage of USB over the more traditional serial port — there is no need for a power supply or voltage regulator on the board. For low powered devices (100-500 mA), you can simply take power directly from the USB port.

Required Software Tools

A few software applications are required to build the software and firmware for this article (all are either open source or free downloads). You can use the supplied hex files if you want to ensure everything is working, but in the long run, you will want to make modifications to support your own devices. Experimenting with the software is also the best way to develop an understanding of how the host interacts with the device, through USB.

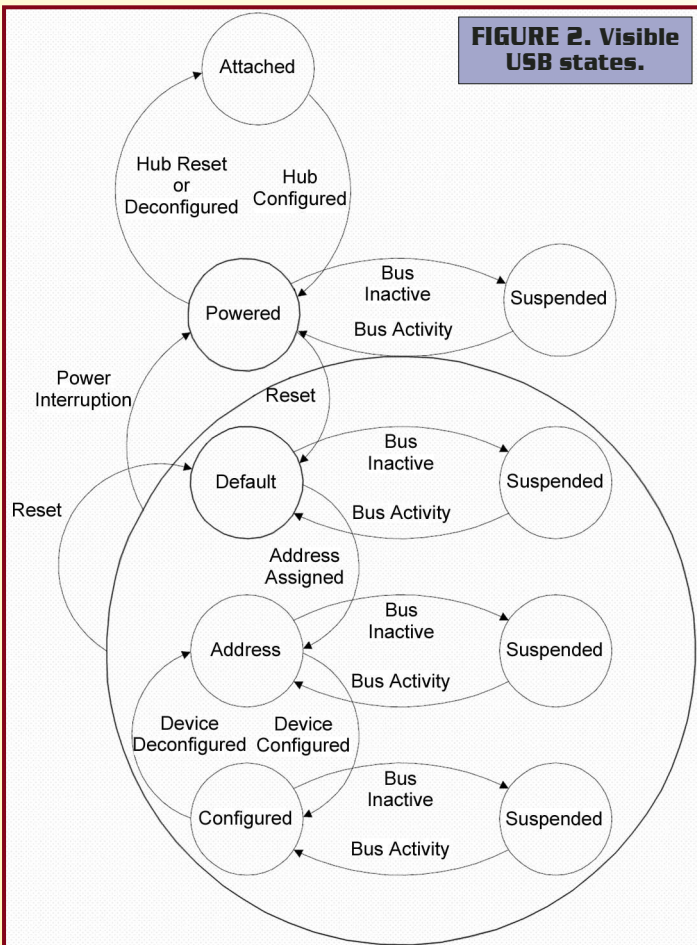
These tools are the bare minimum:

- Visual C#
- Small Device C Compiler (SDCC)
- GPUtils
- Cygwin tools

In addition to the development tools, you will need some way of burning a hex file into the PIC. This is outside the scope of this article. If you don't have a PIC programmer already, they are available from advertisers in this magazine, and can also be found quickly by searching the Internet. See the Resources sidebar for a couple of possibilities.

The Express Edition of Visual C# is adequate for building Windows applications that can interact with a USB device. If you have a more complete version of Visual Studio, then you can use it to automate the builds of the firmware, as well (otherwise, you need to run the Make utility from the command line to build the firmware). Installing and configuring development software is also outside the scope of this article. If you need help, there are many forums associated with the tools that can be exploited.

FIGURE 2. Visible USB states.



USB DEVICE CONTROL

Finding the Parts

The PIC 18F2455 is available directly from Microchip or from Digi-Key. The perfboard is available in RadioShack stores or through their website. All other parts are available from major electronic suppliers, such as Jameco or Mouser.

Firmware Framework

The basic framework closely follows the state transitions described in Chapter 9 of the USB 2.0 specification. The state transitions are shown in Figure 2. The important states are the column of bubbles on the left. When the device is connected to the PC's USB port, the PC and firmware go through a series of negotiations to ensure that the PC knows what kind of device is connected, the interfaces it supports, and the device/product identifiers.

If all goes well (and many things fail when first building USB firmware), then your device will spend most of its time in the configured state — waiting for the PC to ask it to do something. The good news here is that by starting with working firmware, you can spend more time making your devices go.

The basic framework is set up to behave as a Human Interface Device (HID). While this has some minor drawbacks for total throughput between the PC and the PIC, it makes life much easier for Windows application development. By using an HID interface, there are no device drivers necessary for Windows — from Windows 98SE on, HID drivers are built-in. The only thing you have to know is the VID/PID for the device. The VID and PID are set to arbitrary values in the firmware, and you should change them to something appropriate (see the definition of device Descriptor in `usb.h`).

Adding Your Code

There are a few functions in the firmware that you must implement. They are declared in `callbacks.h` and are implemented in `main.c`. The proto-

Listing 1

```
// These are the callbacks expected by the USB HID code. Each must be
// at least stub functions for the firmware to compile and link correctly.
int GetInputReport(byte reportID);
int SetupOutputReport(byte reportID);
int SetOutputReport(byte reportID);
int GetFeatureReport(byte reportID);
int SetupFeatureReport(byte reportID);
void SetFeatureReport(byte reportID);
```

Listing 2

```
// Initialization for a SET_FEATURE request. This routine will be
// invoked during the setup stage and is used to set up the buffer
// for receiving data from the host
void SetupFeatureReport(byte reportID)
{
    if (reportID == 0)
    {
        // When the report arrives in the data stage, the data will be
        // stored in HIDFeatureBuffer.
        inPtr = (byte*)&HIDFeatureBuffer;
    }
}

// Post processing for a SET_FEATURE request. After all the data has
// been delivered from host to device, this will be invoked to perform
// application specific processing.
void SetFeatureReport(byte reportID)
{
    // Currently only handling report 0, ignore any others.
    if (reportID == 0)
    {
        // Set the state of the LED based on bit 0 of the first byte
        // of the feature report.
        PORTAbits.RA4 = (HIDFeatureBuffer[0] & 0x01);
    }
}
```

types of these functions are shown in Listing 1.

If you are not using a particular function (e.g., Input Reports), then you can use a stub function that does nothing. The callbacks are invoked by the framework at three points, when the host is requesting data (GetXXX) and when the host is sending information (PutXXX). The extra callback (SetupXXX) is invoked when data is coming from the host; this is so that a storage buffer can be put in place before the firmware starts transferring bytes.

For example, the host can turn an LED on/off by setting a bit in the feature report. To accomplish

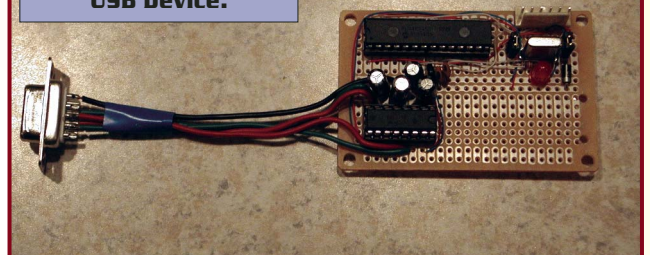
this, `SetupFeatureReport()` and `SetFeatureReport()` can be implemented as shown in Listing 2.

The Basic Board

Getting Your Toes Wet

The basic circuit may look quite simple, but it gives us a way to build a full speed USB device that can exchange information with a host PC.

FIGURE 3. Assembled USB Device.



USB DEVICE CONTROL

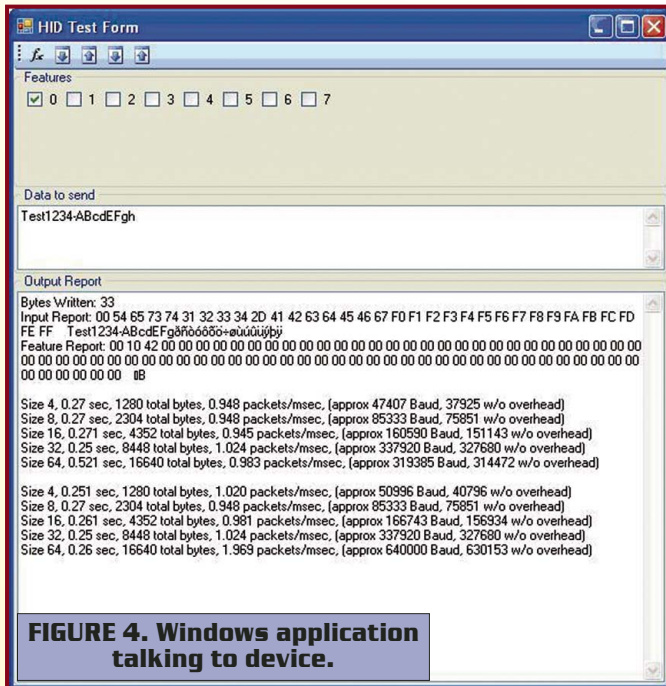


FIGURE 4. Windows application talking to device.

It can be built quickly on a breadboard or it can be implemented on a

off and it can echo a buffer of bytes. Both feature reports and an interrupt interface are supported. Most device control can be supported fully by GET_FEATURE and

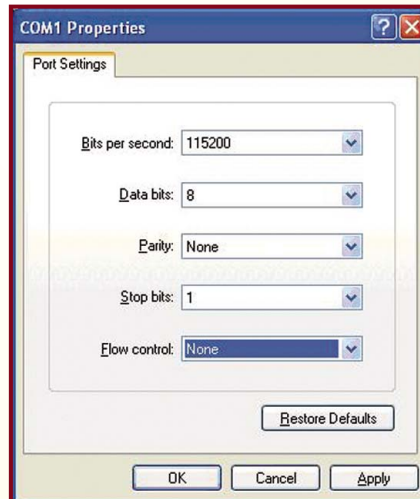


FIGURE 5. Configuring HyperTerminal.

SET_FEATURE on endpoint 0. The implementation of in and out interrupt interfaces on endpoint 1 is there simply as an example.

It is quite possible to take the firmware as-is and make very simple modifications so that you really will never need the serial

debugging capability.

Basic Windows Interface

A C# application that puts the basic board through its paces is shown in Figure 4. Checking and unchecking the box labeled "O" turns the LED on/off. The center text box lets you enter text to send to the device. Note that the number of characters actually sent is limited by the output report length defined by the device — see the definition of HID_OUTPUT_REPORT_BYTES in the firmware.

The buttons on the toolstrip at top run some simple bandwidth tests, sending a buffer out to the device using either feature reports (to endpoint 0) or output reports (to endpoint 1), and either waiting for an echo packet from the device or just streaming it without waiting for a response.

For debugging purposes, the device supports standard Rx/Tx lines over RS232. The firmware is set to use 115 KBaud with no flow control. On the PC you should configure HyperTerminal with the settings shown in Figure 5.

A sample debug output is shown in Figure 6. In the output you can see the device sending information about which descriptors are being requested during initialization, followed by

FIGURE 6. Debug output from the device.

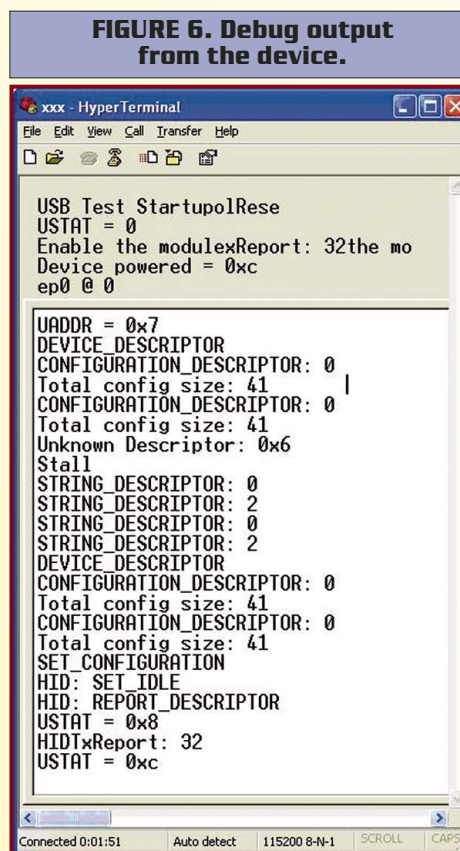


TABLE 2. Parts list for device controller.

PART	QTY
■ Microchip PIC 18F2455 I/SP	1
■ TI SN754410	1
■ LM7805 Voltage Regulator	1
■ BS250 MOSFET	1
■ 15 pF Cap	2
■ 10 µF Cap	1
■ 100 µF Cap	1
■ 3,300 µF Cap	1
■ DB9 Female Socket	1
■ 1N4005 Diode	6
■ W04G Diode Bridge	1
■ MBR1100 Schottky Diode	1
■ Six Pin 0.1" Header	1
■ 2N7000 N-Channel MOSFET	1
■ IRF540 N-Channel MOSFET	1
■ BS250 P-Channel MOSFET	1
■ 78F151J - 150 µH Inductor	1
■ 100Ω 1/4W Resistor	1
■ 1K 1/4W Resistor	1
■ 10K 1/4W Resistor	3
■ 12K 1/4W Resistor	1
■ 51K 1/4W Resistor	1
■ 100K 1/4W Resistor	2
■ T 1-3/4 Red LED	1
■ 20 MHz Xtal	1

USB DEVICE CONTROL

RESOURCES

Several URLs are provided below to help you find parts and information. In addition to these, don't be afraid to search around a bit for USB information.

PARTS

Microchip, Inc. — PICs/Programmers
<http://buy.microchip.com/>

Jameco — Components
www.jameco.com

RadioShack — Components
www.radioshack.com

PROGRAMMERS

Sparkfun — www.sparkfun.com

Olimex — www.olimex.com/

DEVELOPMENT SOFTWARE

Microsoft — Visual C# Express
www.microsoft.com

SourceForge — GPUtills
<http://sourceforge.net/projects/gputils/>

SourceForge — SDCC
<http://sdcc.sourceforge.net/>

Red Hat — Cygwin
<http://sources.redhat.com/cygwin/>

USB INFORMATION

USB.org — www.usb.org

Lakeview Research —
www.lvr.com/index.html



FIGURE 10. Windows app to control devices through USB.

position control for the servo.

Motor

The motor is driven directly by a Texas Instrument's SN74410 quad half-bridge chip. Two pairs of half bridges are coupled together to form a single H-bridge circuit. The PWM1 line from the PIC together with two digital I/O lines are used to control speed and direction. This chip is good to a couple of watts. For larger motors, it should be replaced with either a larger integrated H-bridge or one made of

discrete MOSFETs. The firmware files motor.h and motor.c contain the logic associated with driving the chip.

Servo Motor

R/C-type servos are a stock item in robotics — from steering to drive wheels. These servos require repetitive pulses between 1 and 2 mS. The duration of the pulse determines the angle that the servo will move to (and hold). This implementation uses the PIC's Timer3 to cause an interrupt about 50 times a second. After the interrupt is fired, the servo control line will be pulled high. The duration

of the pulse is then loaded into Timer3. When the next interrupt occurs, the servo control line is pulled low.

While this technique is a bit more complicated than just counting a delay for the duration of the servo pulse, it allows the PIC to keep doing useful things (like send/receive USB packets). The firmware files servo.h and servo.c contain the essential logic.

Solenoid

The solenoid control is a little more complicated than necessary. The reason for this is to demonstrate how a Windows application can display information from the device, as well as send control instructions to it. The PWM2 line from the PIC is used to drive an inductor-based voltage boost. The voltage from the boost circuit slowly charges a large capacitor. As the voltage builds up, a progress bar in the application fills up, giving a visual indication when there is sufficient charge to fire the solenoid. The solenoid I was using gave a satisfactory clack at around 20V (YMMV).

The firmware files solenoid.h and solenoid.c contain the firmware associated with the voltage boost and solenoid control. When implementing this part of the circuit, ensure that you use a capacitor rated for the highest voltage you generate. Adjustments to limit the voltage are made by changing the value of HIGH_SET_POINT in solenoid.c, as well as by modifying the voltage divider resistors that feed into pin AN0 on the PIC.

Conclusion

The PIC 18F2455 takes care of all the low level USB details. By adding a firmware framework, you can quickly interface it to your PC. The set of peripheral controllers (PWM, A/D, Timers, etc.) built into the PIC should be enough for most small to medium projects. Don't be afraid to play around — the PIC can be easily reprogrammed many thousands of times. **NV**

Two views are shown in Figures 8 and 9. The former is a close-up of the circuit implemented on a breadboard. The latter shows it connected to the PC and the devices themselves.

Modified Windows Interface

The C# application used to control the devices is shown in Figure 10. For this application, there are a few changes to the controls. There are still checkboxes for LED control, but a few new controls have been added. There is a voltage meter and actuation button for the solenoid, a speed control for the motor, and a



■ BY LOUIS E. FRENZEL

TV ON A CELL PHONE

I SUPPOSE IT HAD TO HAPPEN. You can do almost everything else with a cell phone these days like play music, take digital photos, send and receive text messages and emails, play games, and even surf the Internet. Why not TV? Some cell phone operators are already supplying short video segments of sitcoms, sports events, and other content for a monthly fee. But such efforts are only just the beginning of what may become a huge new TV industry.



■ **FIGURE 1.** The N92TV cell phone from Nokia. This WCDMA/GSM/GPRS/EDGE phone uses the DVB-H format. It receives TV on 470 MHz which is an available band in Europe.

While most people surveyed over the past years said no to cell phone video, we are going to get it nevertheless. This trend is not only technologically driven, but also driven by the need for cell phone operators to develop new streams of revenue to replace the decelerating rate of new cell phone subscribers and the gradual abandonment of regular wired phones for full wireless.

Take a look at Figure 1. It shows one of Nokia's TV cell phones used in Europe. If that turns you on, you may be interested in how all this works. Read on.

HOW COULD THIS WORK?

Stop and think a minute about the ways that video could be sent to a cell phone. The first thing you might think of is putting a regular TV tuner in a cell phone. TV tuners these days are just a tiny single chip anyway, so it is a good fit. Yet, to get reasonable TV reception, you will need a big antenna. Most over-the-air TV is still mostly in the low VHF bands, so you need an antenna several feet long to get any kind of

acceptable TV reception.

Think rabbit ears on a cell phone. Who wants that? I suppose you could use the earphone cable as the antenna like they do in cell phones with FM radios in them. That will work, but audio reception is far more forgiving than video. Crummy video with noise, snow, distortion, etc., is unacceptable to most. A short wire is just not going to hack it.

Another point to consider is that regular TV is not just formatted for a small screen. Text and screen details are way too small to see on a typical two-inch diagonal LCD screen. On top of that, analog TV is set to be phased out starting next year. The FCC has said that, beginning in 2007, all TVs will be digital using the ATSC (Advanced Television Standards Committee) High Definition (HD) TV standard that is now already in operation in most cities. Few have it, but soon all TVs will be digital only. Converter boxes that translate the HDTV signal into a poorer version for older analog TV sets will be available for those who can't or won't buy a new TV.

One thing's for sure — the com-

plicated HDTV standard was not designed with portable or mobile TVs in mind. While you can jam almost anything into a hand-held, just be ready for the extra size and really short battery life. This standard operates in the existing (mostly VHF) TV bands, so you are still facing the antenna problem. No, HDTV on a handset is not going to happen.

Another obvious solution is just to deliver video over the cell network. This can — and is — being done. Just remember that video eats bandwidth like no other application. A typical digitized color video signal for a QVGA (Quarter Video Graphics Array) 320 x 240 color LCD display put into serialized form needs a transmit rate at a minimum of 30 Mbps. That is just a 15 frames-per-second (fps) display — half the 30 fps we are used to.

Huge bandwidth is required. Luckily, video compression standards like MPEG-2 and MPEG-4 are now available to greatly reduce that rate, but it still means that you will need a serial data rate of 100 to 300 kbps to make it acceptable.

Can a cell phone handle data

that fast? The newer 2.5G and 3G packet data phones can do it. GSM phones now incorporate a fast packet service such as EDGE (Enhanced Data rate for Global Evolution). This is the technology used by Cingular and T-Mobile. The cdma2000 phones use something called 1xRTT and EV-DO (Evolution-Data Only) to transmit fast data. Cellular operators Sprint Nextel and Verizon use this format.

Both use fast data to implement email, Internet access, and digital photo uploads. It will work for compressed video and that is how the current video services are delivered. Cingular and Verizon are already implementing their full 3G phones in major cities. The Cingular system uses wideband CMDA (WCDMA) as the upgrade from GSM/GPRS/EDGE. A faster version called high speed downlink packet access (HSDPA) gives even higher speed in the 10 to 14 Mbps range. The EV-DO cdma2000 is already a 3G technology, so data rates are as high as 2.4 Mbps.

Video over the cellular network can take one of two forms: download for storage in an on-board Flash memory for later viewing or streaming video. Streaming video means that it is always on and in real-time. You watch it as you are receiving it as with most TV. But streaming video is expensive if you are paying by how many network minutes you use.

It also eats up the network capacity very fast. The implication of that is if more than a few subscribers want to watch TV at the same time, the net-

work could run out of capacity and crash. Not a good TV business model. Besides, with the color LCD screen on continuously, the battery life in a cell phone will usually be less than an hour. Not the all-day capacity we are used to. What to do?

The future of cell phone TV will incorporate some of those schemes, but a more successful approach is a whole new broadcast TV system that is expected to launch late this year and roll out in 2007.

DVB-H AND MODEO

Modeo is the name of a new video broadcast service developed by Crown Castle International of Houston, TX. This company owns, leases, and maintains nearly 11,000 cell towers nationwide. Modeo uses the European digital television standard Digital Video Broadcast (DVB). A terrestrial version (DVB-T) is used throughout Europe in regular home TVs.

A modified version is for handhelds (DVB-H), portable, or mobile TVs. This standard digitizes the video, compresses it, and transmits over whatever frequency spectrum is available. Crown Castle owns a 5 MHz segment of bandwidth at 1.67 GHz. It is available nationwide.

What Modeo will do is develop or acquire video content for cell phones and other portable TV devices like car TVs. Then we will be able to talk on the phone, drink coffee, eat a Big Mac, and watch TV while driving 85 mph in our 10 mpg SUVs. In any case, the content will be

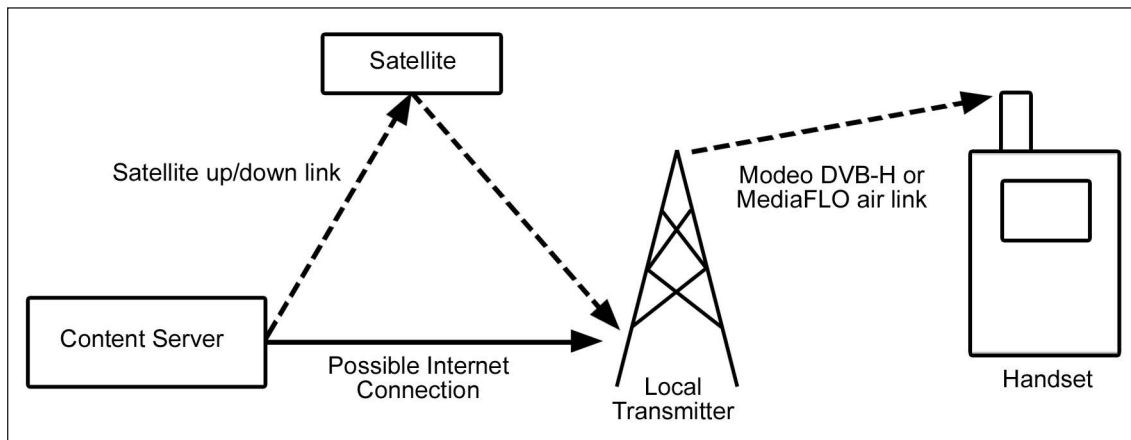
shorter segments of video typically no longer than, say, 20 minutes. It will be news, weather, sports, music videos, and other new material created especially for this medium. And it will be in a design and format to make it very presentable on a small screen. Audio-only channels will also be available — mainly music and probably some podcasts.

This content will be stored on a server at some central location. Then, as Figure 2 shows, it will be distributed by the Internet or a satellite to local broadcast stations set up in the major cities specifically for this purpose. Each station will have its own kilowatt-level transmitter and a tall tower. Typical coverage will be about a 20 mile radius, but that will vary from locale to locale depending upon terrain, buildings, etc. Several towers and transmitters may be needed to cover a large city. Repeaters may be required in cities where lots of tall buildings exist.

The DVB-H standard is designed to use a bandwidth of 5, 6, 7, or 8 MHz. With 8 MHz, it can achieve a data rate up to 15 Mbps. Less bandwidth lowers this proportionally, but it is still fast enough to deliver digitized TV and audio. The video is compressed using a version of MPEG-4 (Moving Picture Experts Group - 4) called H.264 which is an ITU (International Telecommunications Union) video compression standard.

The data rate of a single video signal will be in the 100 to 300 kbps range. This means that if the station can transmit 10 Mbps, then multiple channels can be created. With DVB-H, Modeo will probably have about 10 video channels and multiple audio channels all serially time multiplexed.

■ **FIGURE 2.** How cell phone TV will work. Local transmitters get their programming usually by satellite from a central source. Look for availability of both Modeo and MediaFLO in 2007.



The modulation in DVB-H is orthogonal frequency division multiplexing (OFDM) using QPSK, 16-QAM, or 64-QAM on each carrier. OFDM is the best choice for a mobile or portable TV service. It is extremely robust in conditions like multipath from reflections, fading, noise of all types, and Doppler variations that are inevitable in a moving vehicle.

If cell phone TV is going to be accepted by the public, it must produce good reception at all times. DVB-H also has a feature called multiprotocol encapsulated data with forward error correction (MPE-FEC). It wraps the compressed video data in a packet with a channel address header and a 32-bit CRC (cyclical redundancy check), then adds an error correction procedure that greatly improves the carrier-to-noise (C/N) ratio and the Doppler performance.

DVB-H also uses a technique called time slicing that only turns the receiver on when the channel you are receiving occurs. The transmitter is sending data continuously, but with, say, 10 channels, you will only be watching one of them. That means you can turn the receiver off for 9/10ths of the time. That produces a huge power reduction that makes it possible for a cell phone battery to last two to three hours while watching TV.

Modeo was extensively tested in Pittsburgh, PA in 2005. Later this year, the first Modeo stations will go on the air in New York City and a few other places. It is expected that during 2007, Modeo will roll out 30 more stations nationwide. They just recently announced the availability of the first cell phone ready for Modeo service. It is made by HTC — a leading Taiwan cell phone manufacturer.

It is a regular four band (850/900/1,800/1,900 MHz) GSM/GPRS/EDGE cell phone. Inside is a separate DVB-H receiver and the related hardware and software. The RF tuner is by Microtune and the receiver demodulator/decoder chip is by DiBcom. The digital output is decompressed and otherwise

processed by a Texas Instrument's OMAP850 chip that contains a 32-bit ARM processor and one of TI's famous DSPs.

A NVIDIA GoForce 5500 graphics processor runs the 2.2 inch QVGA screen. The software is Microsoft's Windows Media Video and Digital Rights Management. Windows Media Player 10 Mobile and Windows Media Audio (WMA) software is included. In addition to the video, it will play WMA, MP3, and AAC compressed audio, as well.

The DVB-H receiver with its own antenna stands alone and really doesn't need the cell phone data capability. But it can be used to provide a path back to the TV supplier. This will produce the ability to create interactive two-way TV and some user feedback.

MediaFLO

A more recently announced broadcast video technology and service is from MediaFLO owned by Qualcomm. As you may know, Qualcomm is the CDMA pioneer and its cdma2000 chips and software power most cdma2000 cell phones and basestations in Sprint Nextel and Verizon systems. Their new system is similar to that described in Figure 2.

FLO means forward link only which simply means broadcast or multicast operation.

MediaFLO acquired previous UHF channel 55 in an FCC auction a while back. This 6 MHz chunk of spectrum extends from 716 to 722 MHz. Like DVB-H, it has a high speed data stream up to about 12 Mbps. It is formatted into 20 TV channels and 10 audio channels. It also uses OFDM to ensure reliable reception under a wide range of crummy conditions. The display is what is called QCIF (quarter common intermediate format) — a standardized way to refer to the horizontal and vertical resolutions of a LCD screen. QCIF is 176 x 144 pixels. MediaFLO uses MPEG-4 compression and a 96 kbps data rate for 15 fps. QVGA at 30 fps will also be available. It uses the AAC and AAC+ audio compression formats.

MediaFLO will set up its own nationwide network of stations in major cities. The phones with Qualcomm chips will be available through Verizon and Sprint Nextel and other sources. Services will begin sometime in 2007.

I can't picture myself watching TV on a cell phone. I'm busy and I've got stuff to do ... like email. I will just stay with the BlackBerry. **NV**

8/16-bit EEPROM | Ser. EEPROM | Flash EPROM | GAL / PALCE | Most MCU's | Low Voltage to 1.3V. | DIL dev. w/o Adapter.

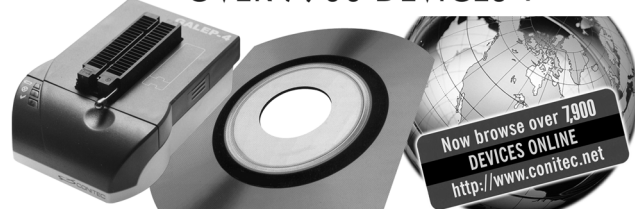
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GETTING STARTED WITH PICs

THE LATEST IN PROGRAMMING MICROCONTROLLERS

■ BY CHUCK HELLEBUYCK

USING THE PIC EXTERNAL INTERRUPT

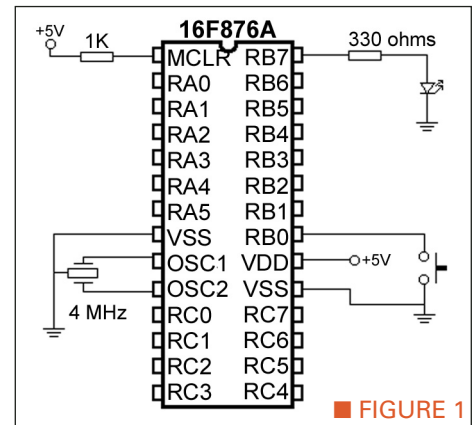
LIFE CAN THROW YOU IN MANY DIRECTIONS and how we deal with it builds our character. This happened to me recently while trying to get this article out for *Nuts & Volts*.

My life was interrupted. My father, who has been battling cancer, lost his battle and passed away. My whole world was rocked. Loss of a loved one is never easy and a parent is devastating. My father taught me the basics of electricity and he taught me so much more. It's in his honor that

I continue to help others with this column.

PIC INTERRUPTS

The same way interrupts in life can happen, external events you don't want to miss in your PIC project can be caught using an



■ FIGURE 1

interrupt. For example, your main program loop is running along fine and then a switch is pressed by a user and you want the main loop of code to respond to it. If you run a loop constantly checking a port for a state change (high-to-low or low-to-high), there is no guarantee that your main loop will be fast enough to see the switch press happen at exactly the same time the main loop polls the I/O pin. This is where hardware interrupts take over. They run in the background and will pause the main loop of code to run an interrupt routine that you write as a separate block of code.

The PIC has one main external interrupt and it's on PortB bit 0 or port pin B0. You can set it up to interrupt on the rising edge (low-to-high) or falling edge (high-to-low) of the interrupting signal. Both PICBasic Pro and the Atom have Basic commands that make this an easy event to control. The program in Listing 1 shows a very simple application for PICBasic Pro.

The schematic is shown in Figure 1. The program simply lights an LED connected to the B7 I/O pin.

When a switch connected to the external interrupt pin B0 is pressed, the program jumps to the interrupt routine and shuts the B7 LED off for a half second and then

LISTING 1: PICBasic Pro Program.

```
\ External interrupt example
\ PortB pin 7 Turn LED on.
\ Interrupt on PORTB.0 (INTE) turns LED off.
\ Program waits .5 seconds and turns LED back on.

led var PORTB.7          \Establish name for portb.7

OPTION_REG = %00111111    \ Enable PORTB pullups, and
                          \ falling edge on B0 interrupt

On Interrupt Goto myint    \ Define interrupt handler
INTCON = $90              \ Enable INTE interrupt

*** Main Loop *****
loop:
  High led                \ Turn LED on
  Goto loop               \ Do it forever

\ ***** Interrupt handler *****
Disable                  \ No interrupts past this point
myint:
  Low led                 \ If we get here, turn LED off
  Pause 500              \ Wait .5 seconds
  INTCON.1 = 0           \ Clear interrupt flag
  Resume                 \ Return to main program
  Enable
```

returns to the main loop of code that lights the LED once again.

HOW IT WORKS

The program initially creates the constant “led” to simplify lighting the LED on B7.

```
led var PORTB.7      'Establish name for portb.7
```

Next comes the initialization of the registers. We want to use the internal pull-up resistors built into the PIC PortB so we do that with a “0” at the most significant bit in the OPTION register. We also want the external interrupt to happen when the switch on B0 is pulled to ground or on the falling edge. The second “0” does that. The rest of the setup establishes the watchdog timer which has nothing to do with the external interrupt.

```
OPTION_REG = %00111111 ' Enable PORTB pullups and
                        ' falling edge on B0 interrupt
```

PICBasic Pro takes care of most of the rest through Basic commands. The Basic command “ON INTERRUPT GOTO label” tells the program where to jump to when the external interrupt occurs. In this example, it jumps to the label “myint.”

```
On Interrupt Goto myint ' Define interrupt handler
```

The interrupts are shut off until the program enables them by setting the proper bits in the interrupt control register “INTCON.” The most significant bit turns all enabled interrupts on, but the only one enabled is the “INTE” external interrupt bit, which is bit 4 in the INTCON register.

```
INTCON = %10010000 ' Enable INTE interrupt
```

Now the program’s main loop of code is run, which is just a loop that continually sets the LED pin to high or on since the LED is connected from the B7 pin to ground through a resistor. This will continue until the switch on B0 is pressed, causing the interrupt.

```
**** Main Loop ****
loop:
  High led      ' Turn LED on
  Goto loop     ' Do it forever
```

When the interrupt occurs, the program finishes the last Basic command and then jumps to the “myint” label. Notice the DISABLE command above the interrupt handler. This prevents any interrupts from happening for any code below it. We don’t

want the interrupt routine to be interrupted by another button press while we are reacting to the first one.

```
' ***** Interrupt handler *****
Disable      ' No interrupts past this point
myint:
```

The interrupt handler just pulls the B7 pin low to shut off the LED and then pauses 500 milliseconds or a half second.

```
Low led      ' If we get here, turn LED off
Pause 500    ' Wait .5 seconds
```

Next, the program clears bit1 of the INTCON register. When the interrupt occurs, the PIC sets a bit (or flag) in the INTCON register. You would use this if more than one interrupt was being used on the PIC, such as the timer interrupt we used in a previous article. By checking the bits, we can determine in our software what caused the interrupt. In this case we know, so we need to clear that flag before exiting the interrupt routine. If we don’t clear it, PICBasic Pro will jump us back into the interrupt routine as soon as we leave it.

```
INTCON.1 = 0      ' Clear interrupt flag
```

All interrupt routines have to end with the RESUME command. This clears the global interrupt bit GIE in the INCON register and puts the program counter back to the main loop where the program was interrupted.

```
Resume      ' Return to main program
```

Finally, the ENABLE command re-establishes interrupts beyond the interrupt routine.

```
Enable
```

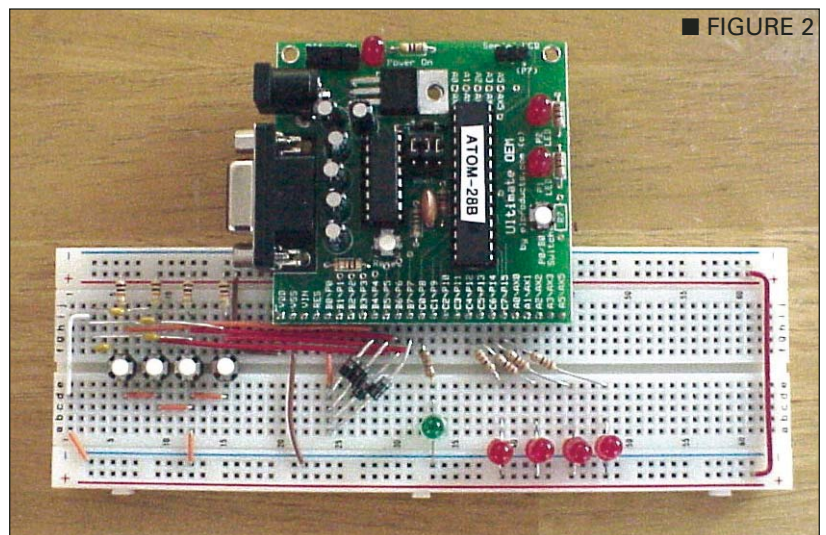
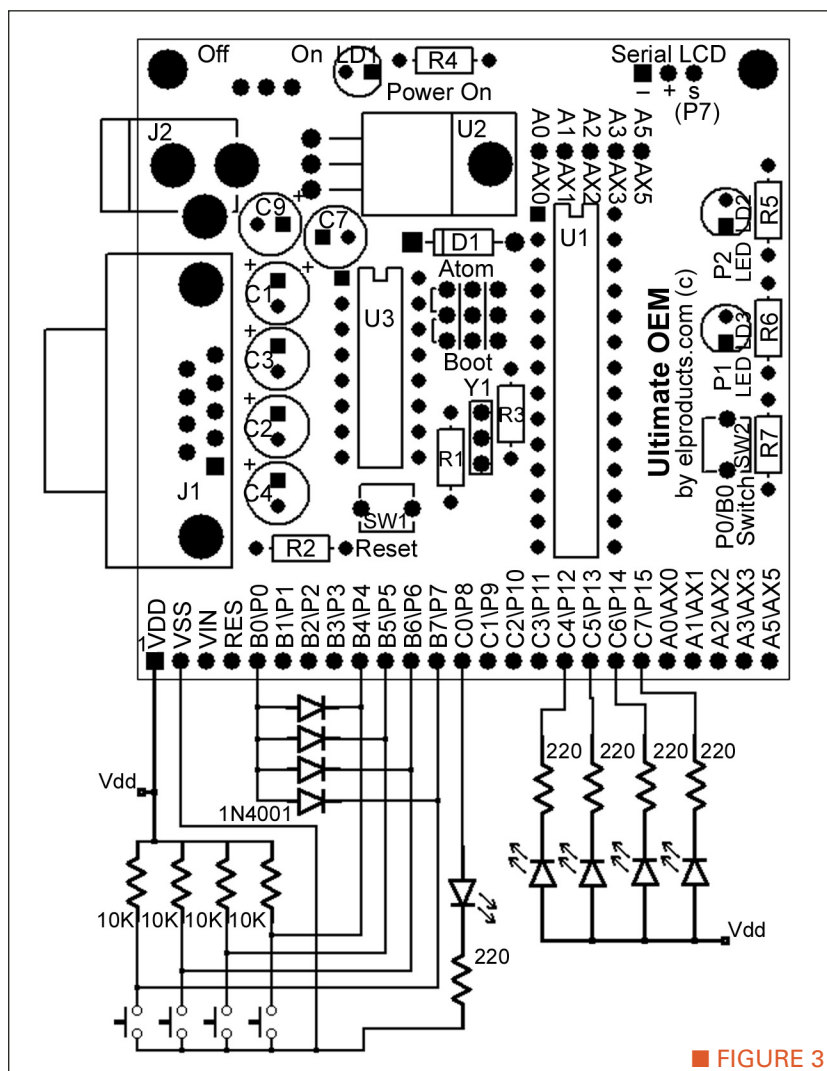


FIGURE 2



■ FIGURE 3

MULTIPLE INTERRUPTS WITH ATOM

This next example shows how easy it is to use the external interrupt (EXTINT interrupt) in Atom Basic. This example also shows a method many beginners would not have thought of: use the external interrupt to capture more than one event by using it as a multiplexed interrupt. The setup is shown in Figure 2 and the schematic is in Figure 3. This same setup can be used with PICBasic Pro, but you will see how the Atom makes it even easier because we don't have to set up all the registers.

The hardware connections tie several switch inputs to the P0 pin through diodes, so different I/O pins can activate the external interrupt. In fact, the project has four switches connected to the P4 through P7 pins, and all of them multiplex connected to the P0 pin through diodes. When any of the switches are pressed, the Atom program is interrupted from what it was doing and reads the P4 to P7 ports to see which switch was pressed. Then it lights LED(s) connected to PIC pins C4 through C7 (Atom P12 through P15) that line up with the switch position(s) to show which switch or switches

were pressed.

While all this is going on, the Atom flashes a separate LED on C0 (Atom P8) in the main loop to represent other functions that can happen while waiting for the interrupt to occur.

HARDWARE SETUP

The schematic shows the connections for this project. The four switches are tied to P4 through P7 with a pull-up resistor to Vdd (five volts). All the switches are connected to the P0 external interrupt pins through the diodes. The diodes have the anodes tied to the B0 pin and the cathode connected to the switches. This allows the B0 pin to see a low (0.7 V) signal when a switch is pressed. The LEDs that indicate which switch was pressed are connected to the C4 through C7 pins. The LED connected to the C0 pin is the continuously-flashing LED in the project picture. All this is done easily with one of my Ultimate OEM modules, but you can build it with a bare PIC 16F876A or Atom 28 pin Interpreter PIC 16F876A chip.

ATOM SOFTWARE

The software program (shown in Listing 2) is really not that complex for something so useful. This is considered an advanced topic for the beginning Atom user, but you will see that it's not that difficult to understand. This is because the Atom software makes using

interrupts very easy.

HOW IT WORKS

The program first establishes and sets up the external interrupt and defines the label of where to go when the external interrupt occurs.

```
OnInterrupt ExtInt, ProgInt ' Setup the external interrupt
```

The external interrupt can happen when the P0 port transitions from a low-to-high or high-to-low state. We choose high-to-low with the SETEXTINT command and the EXT_H2L option. This will make the interrupt happen when we press the switch rather than when we let it go (EXT_L2H).

```
setextint EXT_H2L ' Interrupt on High to Low signal
```

Even though I show pull-up resistors on the schematic for the switches, I initially didn't include one for the P0 pin, which was a mistake. It needs one to make sure the P0 pin is sitting at a known state, so I

turned the internal pull-up resistors on in the software, which is available for P0 through P7 only. I could have left off the switch pull-ups after that, but they there, so I left them in. It works either way, but this shows how to use the SETPULLUPS command and also how to add additional current drive from an external pull-up.

```
setpullups PU_ON  ' Turn on the inter-
                  ' nal pull-ups
```

Now we turn the External Interrupt on with the ENABLE command and the EXTINT option. This is the way the Atom software controls the INTCON register for you.

```
enable ExtInt  ' Turn on the external interrupt
```

We establish a variable “time” to use in a For-Next loop to flash the LED on C0 (Atom P8).

```
time var byte  ' Establish variable Time
```

I write to the port registers directly (TRISC and PORTC) to set up the P8, P12 through P15 ports. This is the same, easy way you would do it if you were programming the PIC in PICBasic Pro. This shows how the Atom gives you full control of the Microchip PIC 16F876A and how, once you learn one compiler, you can easily learn another.

```
trisc = %00000000  ' Make port C all outputs (P8-P15)
portc = %11111111  ' P12-P15 LEDs off, P8 on
```

The main loop of code starts with the “main” label. You can call it what you want, but this makes it easier for me to understand when I look at my code many months later. The main loop just flashes the green LED on port P8 on and off at a 100 millisecond rate. The reason it looks so long is because I break up the 100 millisecond delay into a FOR-NEXT loop with a one millisecond delay repeated 100 times. I do this because of the interrupt.

```
Main
  high 8          ' Green LED turned on
  for time = 1 to 100 ' Start delay loop count
  pause 1         ' Delay 1 millisecond
  next           ' Next delay count
  low 8          ' Green LED off
  for time = 1 to 100 ' Start delay loop count
  pause 1         ' Delay 1 millisecond
  next           ' Next delay count
Goto Main        ' Loop back to main label
```

When an interrupt occurs, the Atom will finish the

LISTING 2: Atom Software Program.

```
OnInterrupt ExtInt, ProgInt  ' Setup the external interrupt
setextint EXT_H2L           ' Interrupt on High to Low signal
setpullups PU_ON            ' Turn on the internal pull-ups
enable ExtInt               ' Turn on the external interrupt
time var byte               ' Establish variable Time
trisc = %00000000           ' Make port C all outputs (P8-P15)
portc = %11111111           ' P12-P15 LEDs off, P8 on

'**** Main Loop of Code ****
Main
  high 8                    ' Green LED turned on
  for time = 1 to 100       ' Start delay loop count
  pause 1                   ' Delay 1 millisecond
  next                      ' Next delay count
  low 8                     ' Green LED off
  for time = 1 to 100       ' Start delay loop count
  pause 1                   ' Delay 1 millisecond
  next                      ' Next delay count
Goto Main                  ' Loop back to main label

disable                    ' disable all interrupts from here down

'**** Interrupt Routine ****
ProgInt                    ' Interrupt routine label
portc.highnib = portb.highnib ' Make LEDs match switches

hold                       ' label for below
if portb.highnib < %1111 then hold ' Wait for switches to be released
Resume                     ' This is how to exit interrupt
```

command it is working on before jumping to the interrupt service routine. If I just used PAUSE 100 as the 100 millisecond delay, then the interrupt could occur when the command started and the interrupt routine would not get processed until 100 milliseconds later. By then, the switch could have been released and the software would not know which switch was pressed. This is why the delay is broken into several commands that take very little time to execute.

The interrupt routine is very short, but I do something not normally done in an interrupt routine — I force it to stay there until the switch is released. First, the DISABLE command is issued to indicate all the commands below it cannot be interrupted.

```
disable  ' disable all interrupts from here down
```

The interrupt service routine starts at label “ProgInt.” The first command looks complex, but is very simple. I use the Atom option of reading and writing to the registers directly. I read the switches P4 through P7, which form the bits of register PortB’s high nibble (upper four bits). Using the equal sign, I make P12 through P15, which form the PortC high nibble — the same state as the bits of PortB. Thus, I’m making the LEDs match the state of the switches. Those that are pressed (low) light the LEDs on P12 through P15.

Those that are not pressed (high) turn off those LEDs on P12 through P15. And I did all that in one command. Easy, huh?

```
ProgInt          \ Interrupt routine label
portc.highnib = portb.highnib \ Make LEDs match switches
```

Now I test the PortB high nibble to see if any of the bits are "0" indicating a switch is being held closed. I do this in a continuous loop by jumping back to the hold label until all the switches are released. When the switches are all released, the RESUME command is executed and the pro-

gram jumps back to the main loop where it was interrupted.

```
hold          \ label for below
if portb.highnib < %1111 then hold \ Wait for switches to
                                   \ be released

Resume        \ This is how to exit
               \ interrupt
```

NEXT STEPS

One thing you can try is to replace the main loop of code with something more interesting than flashing an LED. For example, you could add software to drive an LCD display that shows how many times the switch was pressed. That can be expanded on to do all kinds of things.

The switches can be replaced with light sensors that detect when someone walks by. This way you are creating a people counter with the total count shown on the LCD screen. Do you see how various sections from previous articles can be combined together?

CONCLUSION

I hope this introduction to interrupts in Basic isn't too brief. Over time, you will find interrupts to be extremely useful. PICBasic Pro will actually allow you to use interrupts in assembly so you don't have to wait for the Basic command to complete. This is far more complicated and, in most cases, not needed. Atom Basic does allow you to ignore the PIC register setup and has you read the PIC 16F876A data sheets for register details. This is why I call Atom the perfect beginner PIC compiler. PICBasic Pro costs more and will work with many more PICs, but it's also a professional compiler so it prepares you for programming in assembly much better than Atom. In either case, having the ability to access the PIC features such as interrupts is something other Basic-style modules won't allow. This is why I like these compilers. They get the beginner and even the intermediate user up to speed on what PICs can do.

As usual, email me if you have any questions or comments. I try to answer everything as quickly as possible. See you next month. **NV**

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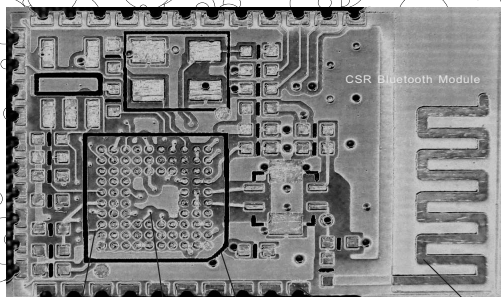
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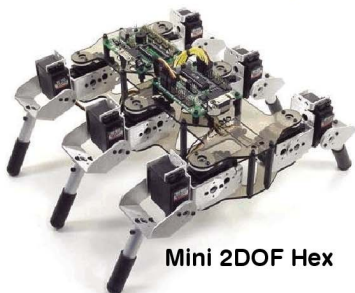


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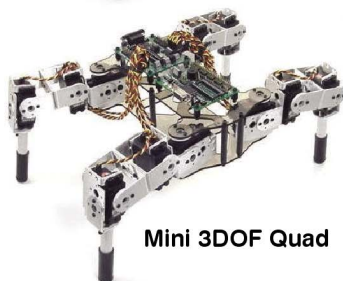
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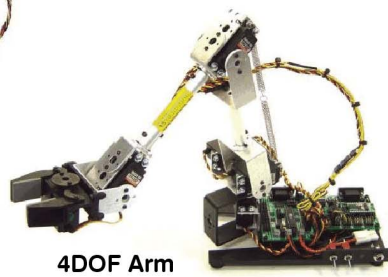
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■ BY PETER BEST

EASY ARM HARDWARE

WELCOME BACK! Last time we perused a set of ARM development tools from Segger and Royal Philips that can be used to debug and develop ARM-based projects. We also did some point-to-point wiring modifications to the basic LPC2136 system we've been building and successfully got some characters to flow from the ARM prototype board's newly added serial port.

As promised, this month we'll combine everything hardware we've covered up to now and put an LPC2136 system on a professional printed circuit board (PCB). Once we've walked around the building of the ARM hardware, we'll put on our ARM programmer hats and put that new piece of ARM hardware to work.

I'm a bit excited about this month's offering, as I've found an excellent way to show you signal and logic patterns in print. The machine behind my excitement is the model CS238 Cleverscope. The Cleverscope CS238 is a Windows-based, USB-attached instrument that is capable

of performing the duties of an oscilloscope, a signal generator, a spectrum analyzer, and a logic analyzer. The really neat thing about the Cleverscope is that I can glean the patterns from the various functions and convert them to pictures that can be printed in the magazine. I won't go into great detail about the Cleverscope this month. I'll talk about the Cleverscope features as I use them in future installments of The Design Cycle.

Beginning with this edition of The Design Cycle, I will supply ExpressPCB files for the PCBs that are presented in each column. In addition, I'll also continue to offer inexpensive, ready-to-roll PCBs via the EDTP Electronics, Inc., website.

Providing the ExpressPCB files will give you a close-up and intimate view of the hardware and PCB layout. Having the actual CAD files will also allow you to customize the original PCBs used in these columns to fit your project's needs.

Okay, I'm really anxious to

show you the new ARM hardware and firmware. So, I'll shut my trap and start the spin for this month's Design Cycle. By the way, from now on the LPC2136 development system we've been working on will be called Easy ARM.

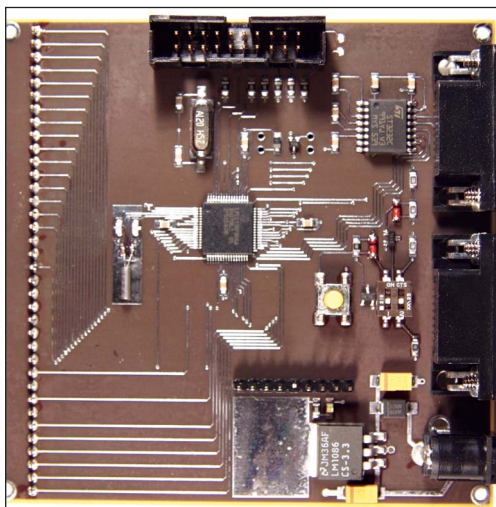
BUILDING UP THE FIRST PRINTED CIRCUIT BOARD PROTOTYPE

We've already proven that our Easy ARM hardware design is workable as we actually built up a point-to-point prototype of the LPC2136 circuitry and pushed some bits through it. Now it's time to put all of what you see in the new Easy ARM schematic (Schematic 1) on a four-layer printed circuit board.

I am by no means perfect. I've rushed through PCB designs only to find that I had forgotten to add a trace or specified the wrong hole diameter for a set of socket pins. As far as designing PCB layouts go, it's not a matter of if you make a mistake, but when you will make a mistake. So, the safe bet is to do your best for the first PCB design spin and have a couple of prototype PCBs made. Use the prototype boards to work out the mistakes and bugs, and then go for the production run. I practice what I preach. The first spin of the Easy ARM PCB is shown in Photo 1.

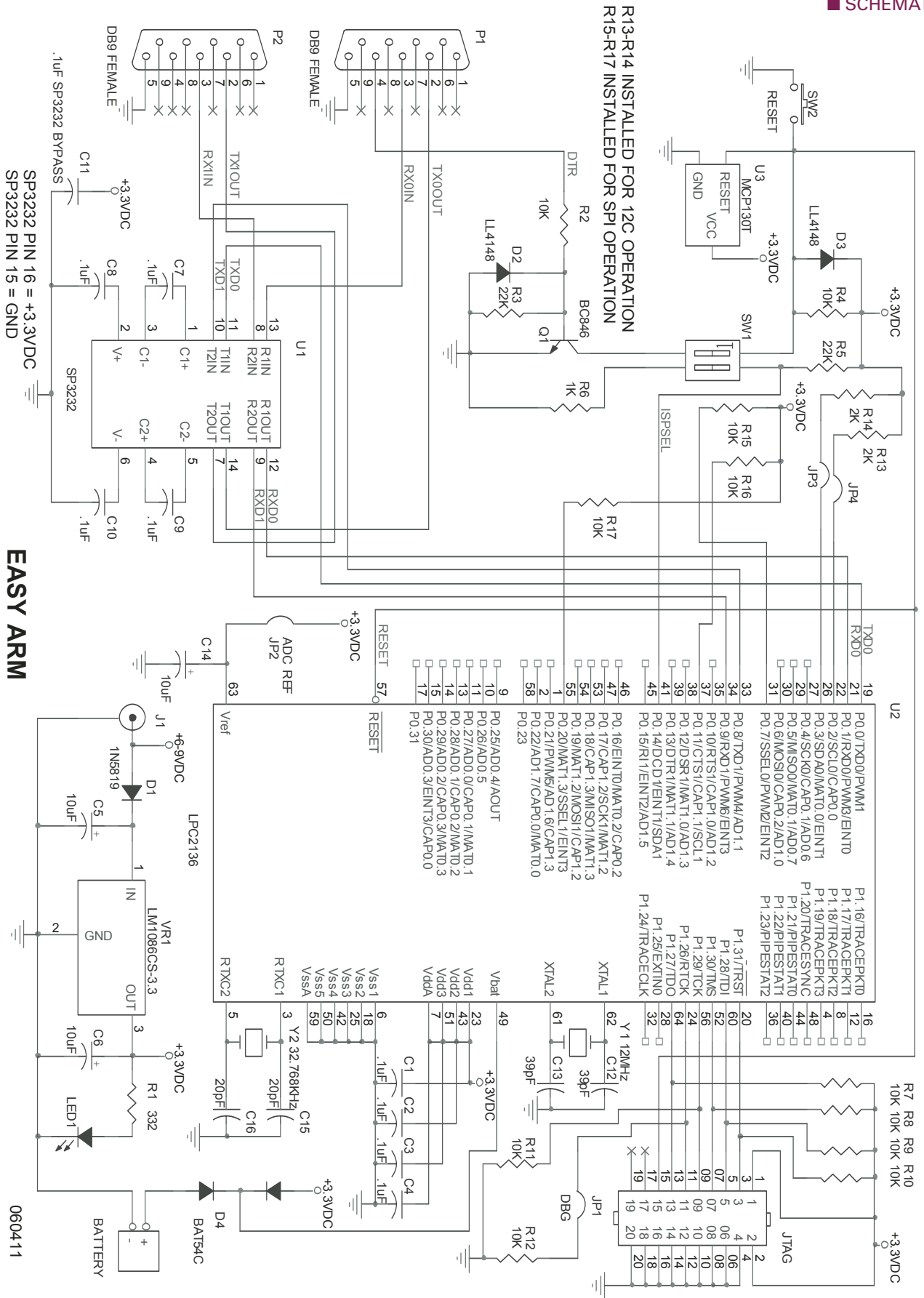
The only changes to our original

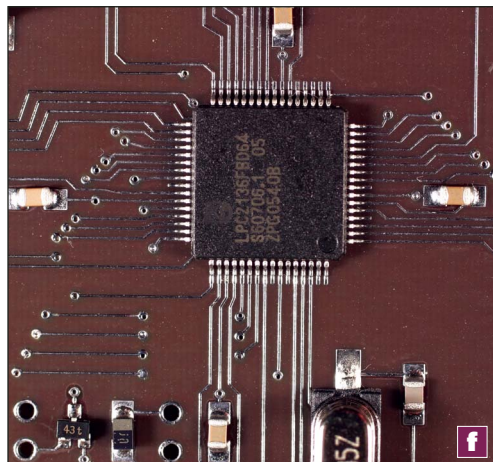
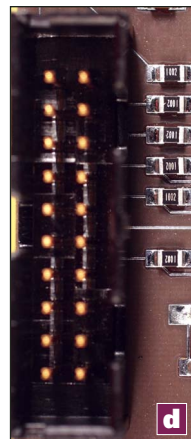
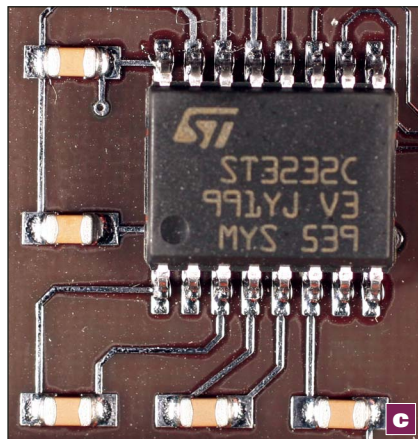
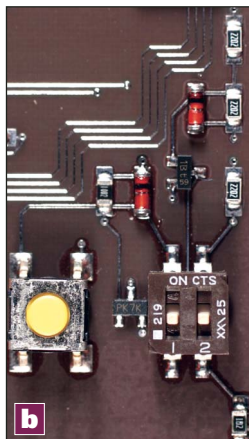
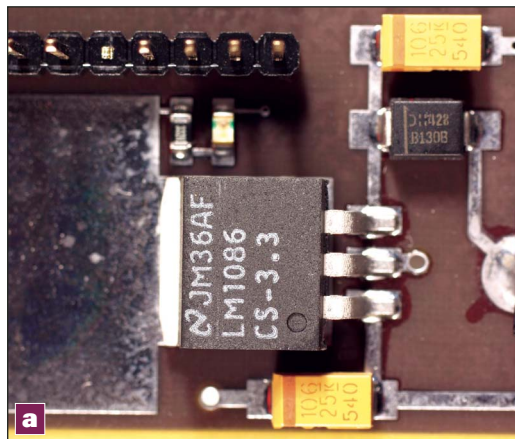
■ All code listings are available on the *Nuts & Volts* website at www.nutsvolts.com



■ **PHOTO 1.** Beauty is in the eye of the beholder. This rather Plain-Jane stage of development may not be a looker to a software engineer, but it is a beautiful thing to an electronics hobbyist. Just in case an OOPS! occurs, the absence of soldermask and silkscreen allows the hardware designer to easily eliminate or reroute the electrical paths that are etched into the board.

SCHEMATIC 1





■ PHOTO 2. (a) Nothing new and exciting here. This layout comes straight from the LM1086 datasheet. (b) The Microchip MCP130T snuggled between the switches eliminates having to install resistor/capacitor reset components and guarantees a valid reset on power-up every time. (c) Nobody does it better. The serial ports should be no-brainers and the ST3232 makes it so. (d) Through-hole components have their place, but it isn't here. (e) This little puppy allows the LPC2136 to keep time all of the time. (f) An aerial view of Grand Central Station. Everything data must pass through here.

point-to-point circuitry in this spin are the additions of a 32.768 kHz crystal and supporting components for the real time clock, a dual-diode arrangement to accommodate the real-time clock battery and the addition of a Microchip MCP130T reset supervisor IC. Let's work our way through the Easy ARM circuitry that is mounted on the PCB from right to left. Macro views of the Easy ARM's subsystems we will look at are provided in the Photo 2 collage.

Photo 2a is a view of the Easy ARM power supply circuitry, which consists of two 10 µF tantalum capacitors, a 1N5819 blocking diode (just in case you plug in a center-negative wall wart), and an LM1086 +3.3 VDC voltage regulator. The pair of four-pin headers above the LM1086's heatsink provides easy access to ground and +3.3 VDC.

The ICSP programming and microcontroller reset circuitry can be seen in Photo 2b. Note the use of 0805 SMT components for the resistors and capacitors. The BC846

transistor is the SOT23 package nestled among the pair of LL4148 small signal diodes, which are also mounted on 0805-size pads. The Microchip MCP130T is also contained within an SOT23 package and is located between the reset pushbutton switch and the two-position ICSP DIP switch. The MCP130T monitors the LPC2136's power supply and guarantees a proper reset is always performed on power-up.

The SP3232 RS-232 IC you see in Photo 2c has just enough internal RS-232 drivers and receivers to support the Easy ARM's pair of serial ports. The only support components that are required by the SP3232 are five .1 µF 0805 SMT capacitors.

The point-to-point prototype of the Easy ARM used a combination of discrete 10K resistors and a 10K SIP resistor package to pull up or pull down certain LPC2136 JTAG signal pins. As you can see in Photo 2d, an array of 10K 0805 SMT resistors has replaced the 10K through-hole SIP resistor package.

As a precaution, I placed a guard ring around the 32.768 kHz real-time clock crystal. The guard ring is ground-

ed and provides a barrier to noise that may upset the real-time clock oscillator under certain low power conditions. The real-time clock crystal can be seen lying inside its guard ring in Photo 2e.

The final shot — Photo 2f — shows the LPC2136 surrounded by its power supply bypass capacitors and 12 MHz crystal circuitry. A 10 µF tantalum capacitor in a 0805 SMT package was added to bypass the analog-to-digital converter reference voltage pin. The BAT54C dual diode's SOT323 package houses a pair of Schottky diodes with their cathodes tied together and pulled out to a pin on the SOT323 package. The BAT54C diode pair routes power to the real-time clock circuitry from either the +3.3 VDC power provided by the LM1086 or from an external battery. The external battery terminal is just to the right of the BAT54C. The jumper block to the left of the BAT54C is used if an external analog-to-digital converter reference voltage is being applied. Otherwise, the analog-to-digital converter reference voltage jumper block is shorted and provides +3.3 VDC to the LPC2136's analog-to-digital converter reference pin.

Even though all of the Easy ARM

SMT passive components are 0805, this size of component is relatively easy to handle and mount using standard hobbyist soldering tools. It is also possible to hand-solder the LPC2136. This takes a bit of skill, a fine-tipped soldering iron, and a magnifier, but it can be done. The Easy ARM components are small. However, the Easy ARM can easily be built by hand with hand-soldering techniques. So, don't let SMT parts keep you from building up an Easy ARM from scratch.

I/O, I/O, IT'S OFF TO WORK WE GO ...

One of the very first things you ever want to know about a microcontroller — other than how to make the serial port work — is how to do simple I/O operations. The LPC2136 is no more difficult to coax bits in and out of than any other microcontroller. To prove it, use the LED layout schematic (Schematic 2) as a guide and hang a current limiting resistor and an LED between +3.3 VDC and the LPC2136's P0.2 I/O pin. The P0.2 pin is open drain so make sure the cathode of the LED is connected to P0.2. Use your free copy of IAR Workbench to compile the LED driver code I've supplied in Listing 1.

Don't concern yourself right now with the code that precedes the LED toggle code. In Listing 1's preliminary code sequence, we are simply setting up the LPC2136 to run in Flash mode without the PLL, in accordance with Royal Philips and the ARM core specification. Right now, we're really only interested in the code beginning with *PINSEL0* = 0x00000000;.

PINSEL0 is referencing the LPC2136's Pin Connect Block. *PINSEL0* and *PINSEL1* address the available P0 I/O pins and *PINSEL2* is responsible for the P1 I/O pins. The inclusion of the Pin Connect Block allows selected I/O pins of the LPC2136 microcontroller to have more than one function. The purpose of the Pin Connect Block is to config-

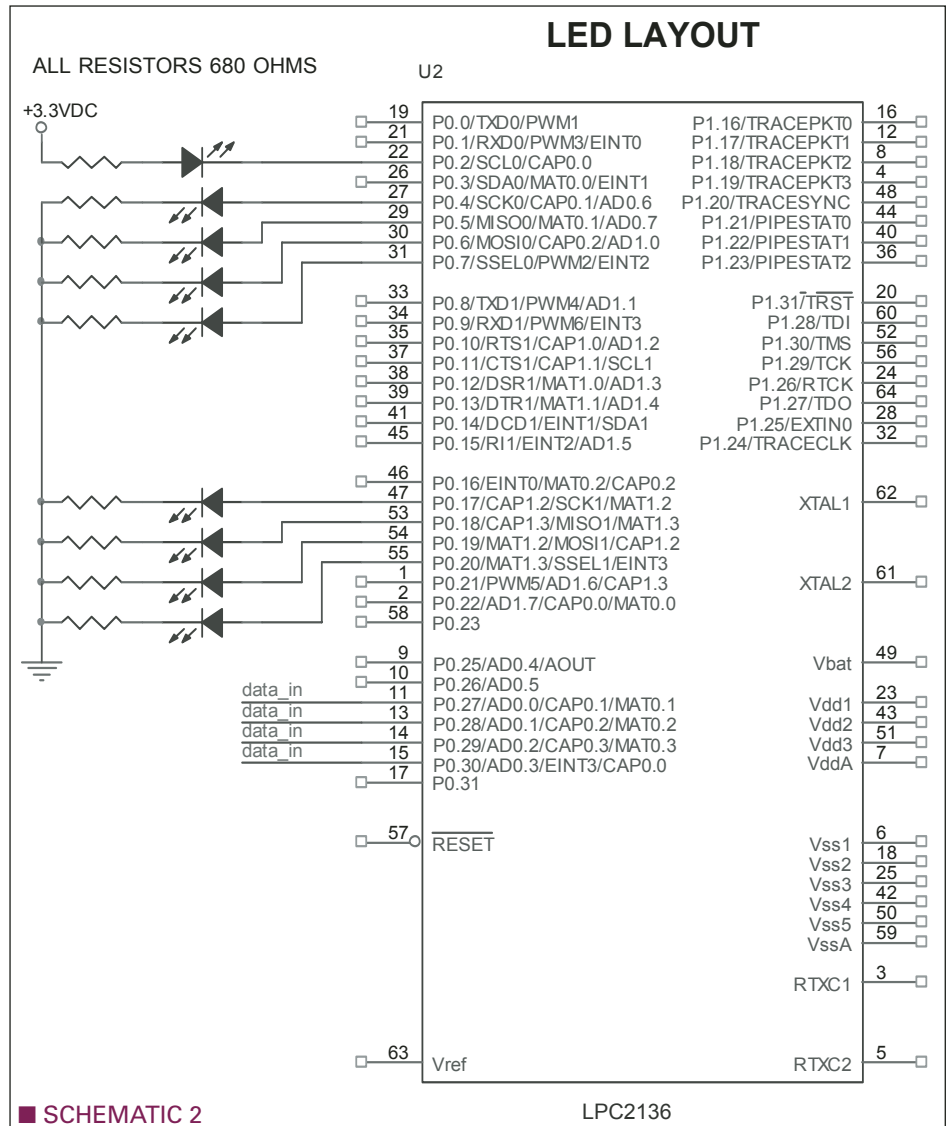
ure a microcontroller I/O pin to operate according to one of the available functions associated with that particular pin.

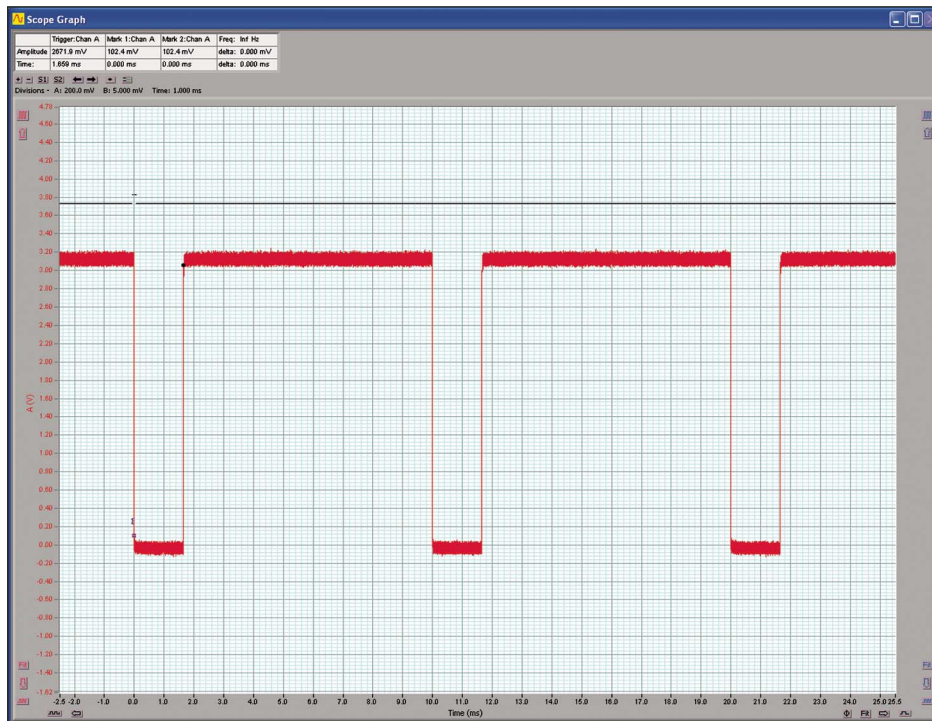
Connections between the pin and the selected LPC2136 on-chip peripheral are controlled by configuration registers which, in turn, control the pin function multiplexers. For instance, in the UART code I provided last time, we loaded the *PINSEL0* register with 0x00050000 (binary 0000 0000 0000 0101 0000 0000 0000 0000) to configure P0.8 and P0.9 as UART1 transmit and receive pins, respectively. To use P0.8 as the PWM4 output and P0.9 as the PWM6 output, we would change bits 16-19 to binary 1010 and the *PINSEL0* contents would change to 0x000A0000 (binary 0000 0000 0000 1010 0000

0000 0000 0000).

To use P0.8 and P0.9 as general-purpose I/O pins, we would simply code 0000 at bit locations 16-19. In our LED toggle code, we don't need to use any of the LPC2136's on-chip peripherals. So, the *PINSEL0* register is loaded with 0x00000000 to reflect that.

IO0DIR is the general-purpose I/O port direction control register for the P0 I/O pins. *IO1DIR* is in control of the direction of the P1 port I/O pins. Bits within each *IODIR* register individually control the direction of each associated port pin. Writing a logical 1 to a bit position puts the port pin associated with that bit into output mode. Our LED toggle code has loaded the *IO0DIR* register with 0x00000004





■ PHOTO 3. The Clevscope measured 1.659 mS between the beginning of the first low-going pulse and the first rising edge. The next falling edge clocked in 8.33 mS later.

(binary 0000 0000 0000 0000 0000 0000 0100). Bit 2 of the IO0DIR register is directly associated with general-purpose I/O pin P0.2 which, in this case, has been assigned as an output pin.

Okay, since pin P0.2 is open drain, all we need to do now is write a 0 to P0.2 to turn on the LED and a 1 to P0.2 to turn it off. There is more than one way to accomplish this.

The simplest way to toggle our LED is to use the LPC2136's IOSET and IOCLR registers. Writing a 1 to bit 2 of the IOSET register will produce a logical high state on P0.2. Writing a 1 to bit 2 of the IOCLR register will produce a logical low state on P0.2. If you've hooked up your LED to P0.2, executing the IO0SET_bit.P0_2 and IO0CLR_bit.P0_2 instructions in Listing 1 will physically demonstrate what I've just described to you.

The downside to using the IOSET and IOCLR registers is that in operations that involve multiple bits being toggled, the I/O pins emitting logical lows lag slightly behind I/O pins emitting logical highs. To get simultaneous output, the solution is to write directly to the IOPIN register. Note that both IOPIN code statements in Listing 1 preserve the state of all of

the bits that will not be changed by logically ANDing them with a 1. Only the bits to be changed are swept to zero in the logical AND operation.

If a bit is to be changed from a 0 to a 1, that bit is logically ORed with a 1, as shown in the first IOPIN statement. The logical OR operation to turn on the LED in the second IOPIN statement is shown for clarity. The AND operation clears the P0.2 bit and turns on the LED. Thus, logically ORing the band of zeroes is unnecessary.

Reading input port pins is very easy to do. The IOPIN register always contains the logical status of every port pin in its domain. In my simplified example, the variable *input_data* holds all of the P0 port pin logic states. To get a particular pin's state, just read the IOPIN register and mask away (logical AND with a zero) the bits you aren't interested in.

As per Schematic 2, load up four sets of LED/current limit resistor pairs between pins P0.4-7 and ground and four more LED/current limit resistor pairs between P0.17-20 and ground. When you're done, compile the advanced LED code in Listing 2.

If you're going to seriously use

peripherals that own a data and address bus like LCDs or external memory devices, you'll need to know how to put multiple bytes on the LPC2136 I/O pins where you want them and when you want them there.

Listing 2 uses the idea behind structures and structure pointers to effectively overlay the bit pattern depicted in the P0_DATA_BUS data type over the LPC2136's IO0PIN, IO0SET, and IO0CLR registers. Notice that the structure elements in the P0_DATA_BUS bit pattern match the connections to LEDs and data input pins shown in Schematic 2.

Once the physical layout of the LPC2136's I/O pins is determined, all that has to be done is to logically assign the respective pins in the P0_DATA_BUS structure element bit pattern and set their direction with the contents of the IO0DIR register.

The *typedef struct* statement creates a data type called P0_DATA_BUS and does not create a typical structure in memory as you would expect. The actual reads and writes are executed against the memory locations that are targeted by the pointers to structures (*DATA_BUS_IOPIN, *DATA_BUS_IOSET and *DATA_BUS_IOCLR), which happen to be the addresses of the IO0PIN, IO0SET, and IO0CLR registers. Thus, the statement *DATA_BUS_IOSET->data_low = led_data* actually sets the bits in the IO0SET register associated with the structure element *data_low* with the value of the lower nibble of *led_data*.

Since we are dealing with multiple bits, we must make sure that if any other bits in the *data_low* structure element are set that were not set by the data we just loaded are cleared. So, we execute *DATA_BUS_IOCLR->data_low = ~led_data*, which clears any bits in the *data_low* structure

element that we did not set with the IOSET instruction.

Reading the levels of LPC2136 I/O pins is a reciprocal of the I/O write operation. The structure pointer `*DATA_BUS_IOPIN` points to the IO0PIN register, which is also under control of the P0_DATA_BUS data type. Thus, the structure element `data_in`, which has an I/O direction of input via the IO0DIR register, is actually a bit pattern that is read directly from the IO0PIN register.

SIGNAL WARPING

Most microcontrollers that support PWM engines make them very easy to use and write code for. The LPC2136 is no exception. Follow along using Listing 3 as we walk through putting one of the Easy ARM's PWM outputs online.

Again, we want to make sure we're not running with the PLL engaged. That allows us to be certain that our PWM pulse width math is based on the PCLK frequency, which is 12 MHz divided by 4, or 3 MHz. We will use I/O pin P0.7 as our PWM output and I have set bit 15 of the PINSEL0 register to make that happen.

The PWMPCR register is used to set the desired PWM output as single or double edged. The difference in a single and double edged PWM signal is that the double edged signal always begins at a logical low level while the single edged PWM signal always begins at a logical high level. Thus, a singled edge PWM signal's duty cycle is controlled by the time between the initial high level and the resultant low level of the pulse. A double edged PWM signal's duty cycle is controlled by varying the timing of both the rising and falling edges of the pulse.

In Listing 3, I have loaded the PWMMR0 register to time out the PWM counter every 30000 clock ticks. The period of our PWM output will be 10 mS ($30000/3 \text{ MHz}$). The frequency of our PWM output is the reciprocal of the period and comes in at 100 Hz. Since we're

■ **PHOTO 4.** When you run this code, you'll see the time update second by second. You could easily make a time-of-day clock from this by setting up the time value registers with the correct time and kicking off the RTC.

operating in double edged mode, let's begin our PWM pulse by keeping it at a low level for the first 5000 clock ticks by loading PWMMR1 with 5000. The PWM pulse will go high when the value within PWMMR1 matches with the number of PWM clock ticks.

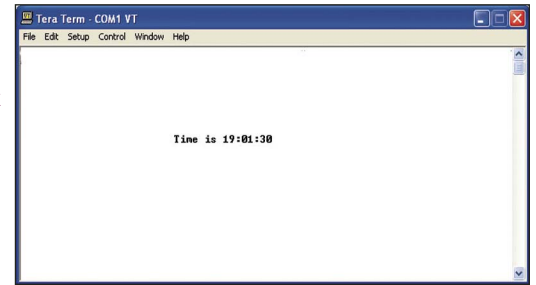
With each clock tick consuming 333 nS ($1/3 \text{ MHz}$), doing the math against the 5000 ticks should give us an initial low time of 1.66 mS. The clock tick value loaded in PWMMR2 determines when the PWM clock will reset and return to a logical low level.

In the case of Listing 3, the PWM pulse will reset at the end of the PWM pulse period. We can use some simple subtraction to get the time that the PWM pulse is high, which works out to be 10 mS - 1.66 mS or 8.33 mS. We can check our subtraction solution by multiplying the remaining 25000 ticks by 333 nS, which also yields 8.33 mS. The proof of the pudding is shown by the Cleverscope screenshot in Photo 3.

TIMED OUT

None of the other components on the Easy ARM got special treatment like the 32.768 kHz clock crystal. So, let's turn on the clock and display the time via a serial port connection to a Tera Term Pro terminal emulator

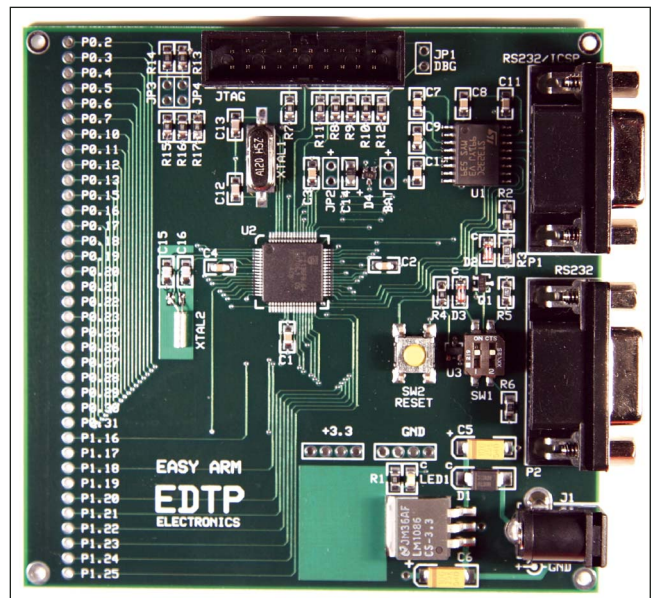
■ **PHOTO 5.** Here's what we've been working towards. It's also what Design Cycle is all about: Taking a project from conception to reality.



window. There's lots of stuff going on in Listing 4. So, let's walk through the code from top to bottom.

The time value we will read originates in the Consolidated Time register. The LPC2136 RTC provides hours, minutes, and seconds in the format depicted by the mask values `hr_mask`, `min_mask`, and `sec_mask`. The Consolidated Time register is accessed via interrupt and the `read_rtc` interrupt handler routine. Invocation of all interrupt service routines is handled by the IRQ Bulk Handler routine `IRQ_ISR_Handler`.

To enable the use of the `printf` function, we must include the `putchar` function in our code. Everything else that is UART is no different here than what you have seen before. Ultimately, UART1 will be configured for 9600 bps, eight data bits, one stop bit, and no parity. As you can see in the `read_rtc` function code, the `printf` function will be called once per second to send the time value to the Easy ARM's serial port.



Since we're simply looking at elapsed time and not really keeping time-of-day time, the configuration of the real-time clock is rather straightforward. The RTC is initially reset and the Interrupt Location Register is cleared. The Interrupt Location Register is used to determine if an alarm or a counter increment caused the interrupt.

Once the RTC is set to interrupt with every passing second, the time

value registers are cleared and the RTC is started. Since we have gone to the trouble to install an external RTC clock crystal, we can choose not to run our RTC from the PCLK clock source. Thus, we must disconnect the RTC clock from the PCLK source and attach it to our external 32.768 kHz clock oscillator.

In the meantime, we've set up the interrupt vector table to recognize the RTC interrupt and enabled

the LPC2136 interrupt mechanism. The clock runs without the need for any additional code and we can do other things, or just sit and enjoy the weather with a while loop as we are doing in this bit of RTC code. I ran the RTC for some time to get the elapsed time you see in Photo 4.

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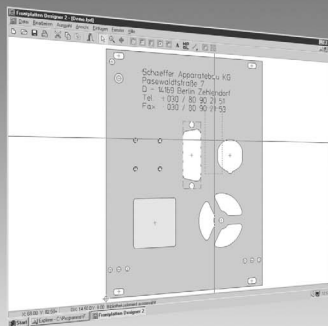
Hopefully, you've gotten your ARMs around the Easy ARM hardware and the sample code I've provided. If you decide to ARM yourself, your Easy ARM will look like the one shown in Photo 5, which incorporates all of the circuitry you see in Schematic 1. The Easy ARM in Photo 5 is available in kit form or fully assembled from EDTP Electronics, Inc., at www.edtp.com. If you haven't already done so, you can get the IAR Embedded Workbench software from IAR Systems at www.iar.com.

The Cleverscope will appear again in future editions of The Design Cycle and if you want to check it out, go to the Saelig website at www.saelig.com for details. And don't forget to go to the Nuts & Volts website and download the code listings and the Easy ARM ExpressPCB layout.

I like to hear from and communicate with the Nuts & Volts readers. You can contact me via email (peterbest@cfl.rr.com) with questions, suggestions, or comments. Until next time, use your head, be brave, and conquer your Design Cycle. **NV**

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SOURCES

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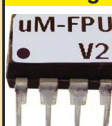
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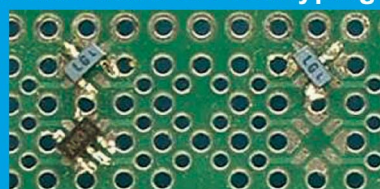
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- ➔ How to calibrate an electromagnetic flowmeter
- ➔ Using a 240 volt transformer at 120 volts
- ➔ LM2917 frequency to voltage regulator
- ➔ Measure electric fields underwater ...
- ➔ Six farad capacitor as scooter battery?
- ➔ Ideas on making a 1.5" x 24" graphic LCD

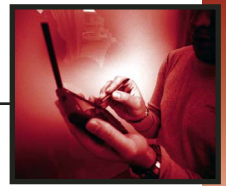
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scription when the magazine first started. A very excellent magazine. I've been in the electronics field for years. And now I'm in the middle of learning assembly language for the Microchip PIC. My boss wants me to learn assembly language before going onto "C" language. I have already bought the back issues on CD. A lot of great information. I started about four variations of LED PIC clock projects. So, as you can tell, I'm a avid electronics hobbyist, too. All I can really say is, great magazine. All the schools should have this magazine. Just can't wait for the next issue. Keep up the good work. Thanks.

Christopher Uplinger

SUPPLIES NEEDS

As an electronic technician in a major facility, I find your magazine very useful and it supplies me with leading edge information for our trade.

I compliment you on a very good publication.

Giovanni Minicucci
Ontario, CANADA

WHAT THE "L" IS GOING ON?

A reader has spotted an error in the on-line layout diagram for my L-meter project (What the L is it?, August 2005). The PC trace between pin 15 of U2 and the bus-wire connection immediately above it should be cut. As shown, the PIC's oscillator output pin is connected to +5 V and the oscillator won't work.

Tom Napier

THEREPING PROVES THERAPEUTIC

I just wanted to say how much I enjoyed Vern Graner's article about his "Thereping" musical instrument. It wasn't so much a "how-to" as a "true-life adventure" about creating a unique application step-by-step.

So many of the projects in *Nuts & Volts* seem to have sprung forth fully-formed from the head of the author that

it's a little discouraging to us less-accomplished folk. The Thereping's evolutionary journey — from inspiration to completion — with problems rearing their ugly heads and solutions being found, is an important lesson in project development ... and a reassurance that not everything — few things, in fact — work perfectly the first time you flip the switch!

C. David McDermott

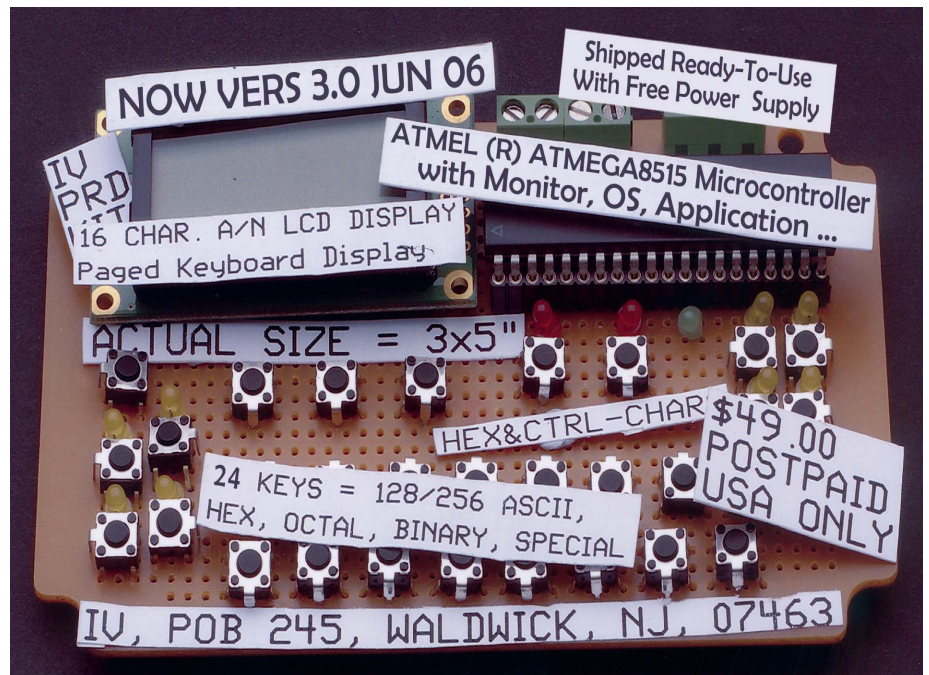
LOVE THOSE PICs

I started looking at your new column "Getting Started With PICs" by Chuck Hellebuyck.

I liked it so much I subscribed to *Nuts & Volts*!!!

Thank you and keep the great PIC articles coming.

Ken Manuelian K1UM



"THERE IS NO ROYAL ROAD TO DESIGN"EUCLID (c 300 bc)
"but, "THERE IS A CHEAP TOLL ROAD"CLARK (c 2000 ad)
UML or BNF?

SEE HERE: : (THIS IS A COMMENT)

; Teach your kid that American Design needs to be much better than
; "Good enough for government work." Perhaps the result will be
; firms and engineers that can design a SUV, a LEVEE, or a Robot.
; BNF simple example
: Begin

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& : _ CODE
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where BREADBOARDS ::= BB2; BB3; BB4; BB5; ...

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Starting with the first *SERVO* issue — November 2003 — all of the issues through the 2004 calendar year are now available on a CD that can be searched, printed, and easily stored.

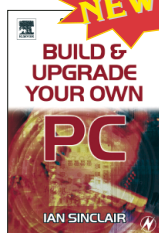
This CD includes all of Volume 1, issues 1-12 and Volume 2, issues 1-12, for a total of 14 issues. The CD-Rom is PC and Mac compatible. It requires Adobe Acrobat Reader version 6 or above. Adobe Acrobat Reader version 7 is included on the disc.

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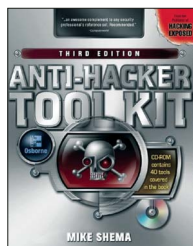
Build & Upgrade Your Own PC — Fourth Edition by Ian Sinclair

Ian Sinclair's "Build Your Own" books have established themselves as authoritative and highly practical guides for home and small business PC users and IT technicians alike. *Build & Upgrade Your Own PC — Fourth Edition* is based around building and upgrading to the latest systems, such as Pentium 4 or AMD Athlon XP motherboards running Windows XP and Windows 2000 Professional. As well as guiding you around the inside of your PC base unit, Ian Sinclair also covers setup, and security issues and peripherals. **\$34.95**



Anti-Hacker Tool Kit Third Edition by Mike Shema

Stop hackers in their tracks! Organized by category, *Anti-Hacker Tool Kit, Third Edition* provides complete details on the latest and most critical security tools, explains their function, and demonstrates how to configure them to get the best results. It is completely revised to include the latest security tools, including wireless tools. This book also includes new tips on how to configure the recent tools on Linux, Windows, and Mac OSX. **\$59.99**

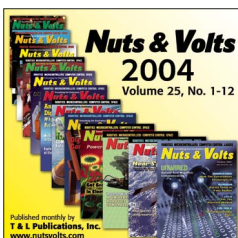


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Nuts & Volts CD-Rom

Here's some good news for Nuts & Volts readers!

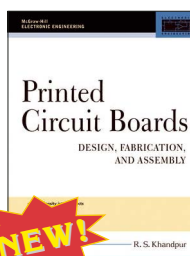
Starting with the January 2004 issue of Nuts & Volts, all of the issues through the 2004 calendar year are now available on a CD that can be searched, printed, and easily stored. This CD includes all of Volume 25, issues 1-12, for a total of 12 issues. The CD-Rom is PC and Mac compatible. It requires Adobe Acrobat Reader version 6 or above. Adobe Acrobat Reader version 7 is included on the disc. **\$29.95**



ELECTRONICS

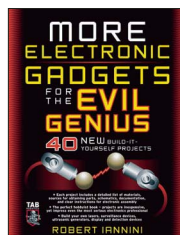
Printed Circuit Boards by R. S. Khandpur

The printed circuit is the basic building block of the electronics hardware industry. This is a comprehensive, single volume self-teaching guide to the art of printed circuit board design and fabrication — covering the complete cycle of PCB creation, design, layout, fabrication, assembly, and testing. Clear and concise, *Printed Circuit Boards* leads readers through the complete cycle of PCB creation, from design, layout, fabrication, and assembly to final testing. Skirting dense mathematics, the text provides insight and guidance on design challenges brought about by the ever-increasing density of today's microelectronics. **\$99.95**



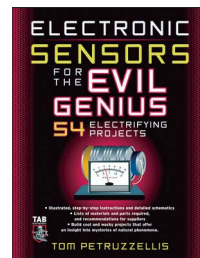
MORE Electronic Gadgets for the Evil Genius by Robert E. Iannini

This much anticipated follow-up to the wildly popular cultclassic *Electronic Gadgets for the Evil Genius* gives basement experimenters 40 all-new projects to tinker with. Following the tried-and-true Evil Genius Series format, each project includes a detailed list of materials, sources for parts, schematics, documentation, and lots of clear, well-illustrated instructions for easy assembly. Readers will also get a quick briefing on mathematical theory and a simple explanation of operation along with enjoyable descriptions of key electronics topics. **\$24.95**



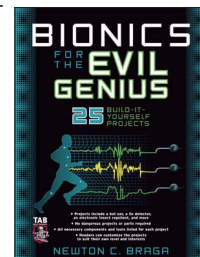
Electronic Sensors for the Evil Genius — 54 Electrifying Projects by Thomas Petruzzellis

Nature meets the Evil Genius via 54 fun, safe, and inexpensive projects that allow you to explore the fascinating and often mysterious world of natural phenomena using your own home-built sensors. Each project includes a list of materials, sources for parts, schematics, and lots of clear, well-illustrated instructions. Projects include rain detector, air pressure sensor, cloud chamber, lightning detector, electronic gas sniffer, seismograph, radiation detector, and much more. **\$24.95**



Bionics for the Evil Genius by Newton C. Braga

Step into the future — (or the past, if you have a touch of Dr. Frankenstein in your soul) — with these 25 incredibly cool bionic experiments! Demonstrating how life forms can be enhanced, combined, manipulated, and measured with electronic and mechanical components, these inexpensive projects from internationally renowned electronics guru Newton Braga provide hours of fun and learning. Totally safe, *Bionics for the Evil Genius* guides you step by step through 25 complete, intriguing, yet low-cost projects developed especially for this book — including an electric fish, a bat ear, a lie detector, an electronic nerve stimulator, a panic generator, and 20 other exciting bioelectric/mechanical projects! **\$24.95**



Small Antenna Design by Douglas Miron

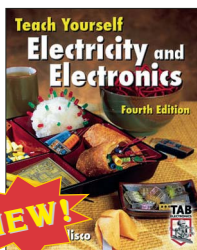
Small Antenna Design covers antenna design techniques from very low frequency (below 300 kHz) to microwave (above 1 GHz) ranges. Special attention is given to antenna design for mobile/portable applications. As wireless devices and systems get both smaller and more ubiquitous, the demand for effective, but small antennas is rapidly increasing. This book will describe the theory behind effective small antenna design and give design techniques and examples for small antennas for different operating frequencies. Design techniques are given for the entire radio spectrum. **\$69.95**



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Teach Yourself Electricity and Electronics — Fourth Edition by Stan Gibilisco

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Intuitive Analog Circuit Design by Marc Thompson

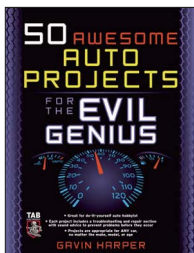
This book introduces analog circuit design with a minimum of mathematics. It gives readers an intuitive "feel" for analog circuit operation and rules-of-thumb for their design. The author uses numerous analogies from digital design to help readers whose main background is in digital make the transition to analog design. The application of some simple rules-of-thumb and design techniques is the first step in developing an intuitive understanding of the behavior of complex electrical systems. This book outlines some ways of thinking about analog circuits and systems that hopefully develops such "circuit intuition" and a "feel" for what a good, working analog circuit design should be. **\$59.99**



AUTOMOTIVE

50 Awesome Auto Projects for the Evil Genius by Gavin D J Harper

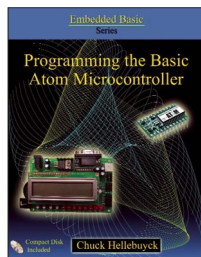
The Evil Genius format is the perfect "vehicle" for 50 incredible automotive projects that are compatible with any car, no matter what make, model, or year. Focusing on low-cost, easily obtained components, *50 Awesome Auto Projects for the Evil Genius* lists the items needed to complete each project along with a troubleshooting and repair section. **\$24.95**



MICROCONTROLLERS

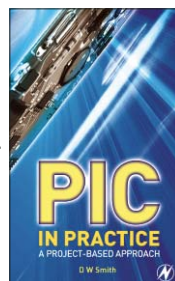
Programming the Basic Atom Microcontroller by Chuck Hellebuyck

Through his unique way of making the complicated understandable, Chuck takes the reader through the inner workings of the Basic Atom by explaining the Microchip PIC Microcontroller and its roll in the Atom module. From there, Chuck explains the various PIC based Basic Atom modules and how to use the Basic Atom compiler. Chuck then delivers 13 projects the reader can build and learn from. The reader can then use this knowledge to develop their own Basic Atom projects. **\$39.95**



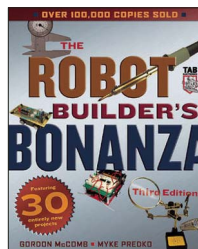
PIC in Practice A Project-based Approach Second Edition by David W. Smith

PIC in Practice is a graded course based around the practical use of the PIC microcontroller through project work. Principles are introduced gradually, through hands-on experience, enabling students to develop their understanding at their own pace. The book can be used at a variety of levels and the carefully graded projects make it ideal for colleges, schools, and universities. Newcomers to the PIC will find it a painless introduction, whilst electronics hobbyists will enjoy the practical nature of this first course in microcontrollers. **\$29.95**



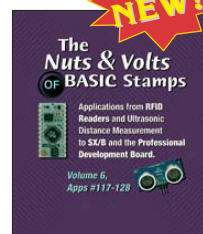
Robot Builder's Bonanza Third Edition

by Gordon McComb/Myke Predko
Everybody's favorite amateur robotics book is bolder and better than ever — and now features the field's "grand master" Myke Predko as the new author! Author duo McComb and Predko bring their expertise to this fully-illustrated robotics "bible" to enhance the already incomparable content on how to build — and have a universe of fun — with robots. Projects vary in complexity so everyone from novices to advanced hobbyists will find something of interest. Among the many editions, this book features 30 completely new projects! **\$27.95**



Nuts & Volts of BASIC Stamps — Volume #6 by Jon Williams

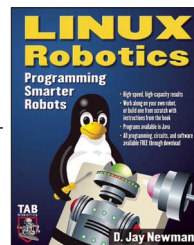
Nuts & Volts of BASIC Stamps — Volume 6 includes articles #117-128, written for 2005. Article topics consist of RFID Readers and Ultrasonic Measurement, SX/B and the Professional Development Board, the advanced MIDI receiver, programming the SX microcontroller in BASIC, mastering the MCI4489 display driver, and more! The Nuts & Volts of BASIC Stamps books are a favorite Parallax technical pick and are a tremendous technical resource for all PBASIC programming projects. **\$14.95**



ROBOTICS

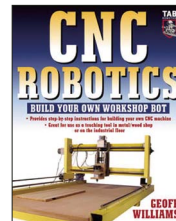
Linux Robotics by D. Jay Newman

If you want your robot to have more brains than microcontrollers can deliver — if you want a truly intelligent, high-capability robot — everything you need is right here. *Linux Robotics* gives you step-by-step directions for "Zeppo," a super-smart, single-board-powered robot that can be built by any hobbyist. You also get complete instructions for incorporating Linux single boards into your own unique robotic designs. No programming experience is required. This book includes access to all the downloadable programs you need, plus complete training in doing original programming. **\$34.95**



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TECH



FORUM

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All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nutsvolts.com. All *diagrams* should be computer generated and sent with your submission as an attachment.

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To be considered, all questions should relate to one or more of the following:

- ① Circuit Design
- ② Electronic Theory
- ③ Problem Solving
- ④ Other Similar Topics

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■ Include your Name, Address, Phone Number, and email. Only your Name, City, and State will be published with the question, but we may need to contact you.

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■ Questions are subject to editing.

ANSWERS

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■ Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

I have a Palm Vx that I want to use for monitoring, logging, or to calculate mileage on a scooter. Any suggestions on the software I could use and how to use the com port? It would also be cool to use it as a speedometer or RPM meter!!

#6061

Luc
Québec, Canada

I have two JumpDrives and was wondering if there is a chip to make it work like a USB JumpDrive MP3 player. I see that they sell them, but I want to build one. Does anyone have a schematic or any ideas?

#6062

Rajesh

I have a spot welder that I want to use on delicate metal. The trigger is not reliable due to its unpredictable "on" time. Is there a way to build a timer that would regulate the "on" time to very short but accurately repeatable (one shot) bursts?

#6063

Les Wolfe

I recently got hold of some junk laptops and was hoping to use the LCD monitors for other applications. Where can I find schematics or possibly a standard computer interface that could be hooked to the ribbon cable? I took apart one of the

monitors and found the following info: Hitachi TX36D86VC1CAB; DP/N 000639RD Rev. A00.

Any ideas?

#6064

Gregg
Wisconsin

I have been very successful in using software to account for contact bounce in switches when designing digital microcontroller circuits. But I recently read a statement in a book that said switch contact bounce could "easily be eliminated by the fitting of a small capacitor" into the circuit. No details were given. I experimented for hours at the oscilloscope using a variety of capacitors, but never came close to eliminating the contact bounce. Is anyone familiar with using a capacitor to eliminate bounce? If so, how do you determine the value of the capacitor, and how is it placed into the circuit in relation to the switch?

#6065

Judy May W I O R O
Union, KY

I am looking for a circuit or schematic for a touch switch module that will work for compact florescent bulbs; just with OFF/ON and will operate with the 115 VAC coming into the lamp. The module should connect to the metal base of the lamp to operate.

#6066

Terry Arnall KB6EBZ
Hayward, CA

My Olympus 3030 digital camera broke down the other day. The LCD display still works so I want to salvage it.

It is a SANYO 3" LCD with the markings 217FAXB 044A01A on it. Any ideas where to get information to make it work? I would like to use it as a regular display.

#6067 Ronald Wijngaarde
Houten, The Netherlands

>>>> ANSWERS

[#4065 - April 2006]

As a police officer who works one-third of the time on the mid-night shift, I've taken to playing a CD with a single, large file containing pink noise to drown out the daytime noises allowing me a better period of sleep. While it works, the reset noise — as the file is again queued — is annoying. Pink noise seems to work better than white in masking sounds.

Simply detuning a receiver works for white noise, until the taxi cab or bus transmits right outside

my house. I'm looking for a way to generate noise, preferably pink noise, without a radio.

I had this exact problem as I used to travel on business and often stayed in noisy hotels. Raising the noise floor with a pink noise generator was a perfect solution for me. The first solution I tried was building a digital pink noise generator. A kit such as the Velleman model 4301 is very similar to the first one I created. The Velleman kit is available from many online vendors for around \$15. Here are a few links:

www.qkits.com/serv/qkits/velleman/pages/k4301.asp

www.elexp.com/kit_4301.htm

www.hobbytron.com/vk4301.html

This kit is easy to build, is small in physical size, and is inexpensive. However, I found that with the digitally generated white/pink noise systems, I could hear a "repeat" point that I personally found somewhat annoying. I prefer the "old-school" analog noise systems that simply amplify the junction noise of a semiconductor

(like a transistor). Though I couldn't find anyone offering a simple kit of this type of noise generator, I did find some example schematics online at:

www.web-ee.com/Schematics/Pink%20Noise/pink.htm

<http://world.std.com/~reinhold/waynesrngcomp.gif>

I also discovered an app note from Maxim on how to build a simple analog noise generator that uses the noise from a reverse biased Zener diode:

www.maxim-ic.com/appnotes.cfm/appnote_number/3469

When I was traveling I had a laptop computer so I explored options for noise generators that were software based. There used to be a few simple programs floating around that were completely free, but now most have moved to a "shareware" model. I did find a free version that is part of a room acoustic properties analysis tool that is available at <http://homepage.ntlworld.com/john.mulcahy/roomeq>. Though this is clearly "overkill" for just making noise to mask sounds for sleeping, it is a

[#5063 - May 2006]

I would like to monitor the voltage and current of my solar electric system. The open circuit voltage is 270 VDC, under load at 230 VDC, and current is 11 amps. Can someone suggest an input circuit which provides isolation and protection for the PIC16F688 I plan to use?

A Hall-Effect sensor seems to be the obvious choice. I selected a Magnetics, Inc., ferrite toroid — ZW42106-TC — which is similar to one I used. Check out www.mag-inc.com. The hole in the toroid is one-half inch diameter, which should accommodate the 11 amp wire (Figure 1). If you cut the slot with a wet tile saw, you probably would not break

it. The toroid is ceramic and breaks easily. The sensor is 0.062 thick so one pass with the saw should be sufficient. Mount the toroid securely because you will be measuring the Earth's magnetic field, as well as the current. The PIC can calibrate that out so I did not provide a null adjustment.

The Hall-Effect device output is half the supply voltage, so you will want a regulated five-volt supply. The sensor output is five millivolts per

gauss. I don't know what the output will be in the arrangement shown (Figure 2), so you will have to experiment. The gain of the amplifier is adjustable, up to 100, via R5. I used SSM2135 but almost any low noise amp will do. The filter, R6, R7, C3, and C4 is intended to remove any AC picked up by the input wires, but use shielded wire to minimize pickup.

Russell Kincaid
Milford, NH

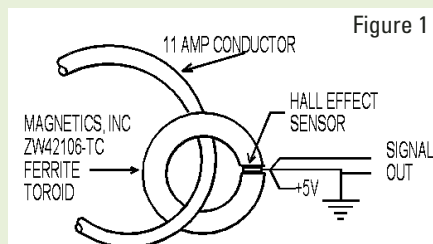
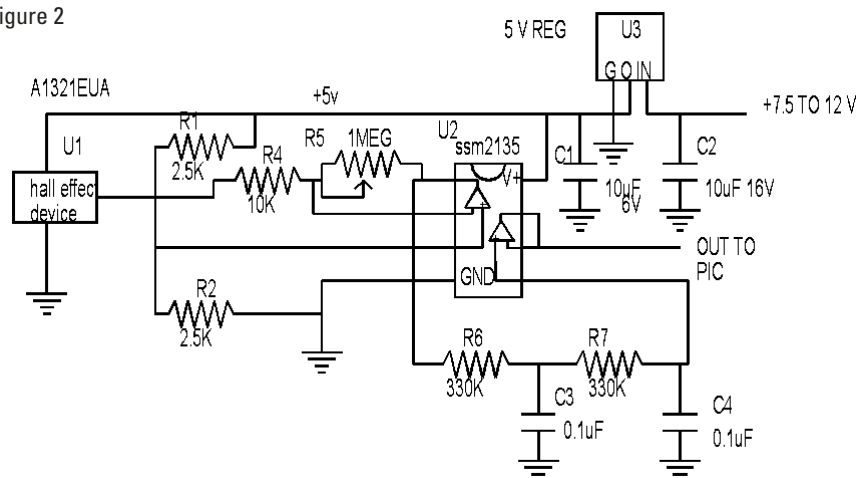


Figure 1

Figure 2



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free solution and is VERY versatile! Of course, you can also use a recording of pink noise played back with a program like "winamp" using a "cross fade" plug-in to cause the end of the "song" to overlap with the beginning so you get a continuous noise source. Winamp is available at www.winamp.com and a cross fade plug-in for it is available at www.winamp.com/plug-ins/details.php?id=146142 Hope this helps. Here's to a good day's sleep!

**Vern Graner
Austin, TX****[#5064 - May 2006]**

How are fireworks controlled in the big July 4th shows? They must be computer controlled because the rockets, roman candles, etc., go off at closely spaced times. What is the interface between the fuses and computer; and, how are the signals distributed?

#1 Most of the large shows are fired with computer controlled firing systems from companies like FireOne, PyroMate, and many others. The actual devices are ignited by "E-matches," which are typically actuated by anywhere from 12V to over 300V signals at about one amp.

The E-matches are characterized by a "no-fire" current, which specifies a safe current that can be used for continuity testing, and an "all-fire" cur-

rent at which all devices should fire. Given the need for extreme safety — we are dealing with explosives here — these systems have to be built for very high reliability under sometimes very adverse conditions. The interface between the computer and the E-match may be all electronic, or electro-mechanical, using relays for the actual firing circuit. The signals are distributed via multi-wire cables, cat-5 cables, telephone wire, two-strand wire, or wireless, depending on the system being used. The software to choreograph the shows is very complex and expensive, as it has a very small market.

**Tom Dimock
Ithaca, NY**

#2 I would suggest you try the following websites. Not only is there a lot of ideas on this matter, there are also safety tips/issues and such. Better safe than sorry! For a simple firing system, try www.pyrouniverse.com/f-system.htm I would highly suggest you take a look at their home page too — great info. Another site that I like is www.skylighter.com

For the Nichrome wire (will light a fuse when current is applied), check out www.unitednuclear.com

Hope it helps and Happy Fourth!

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AMATEUR RADIO AND TV

Atomic Time	43
PolarisUSA Video, Inc.	11
Ramsey Electronics, Inc.	12-13
Surplus Sales of Nebraska	32

BATTERIES/ CHARGERS

Cunard Associates	52
-------------------------	----

BUSINESS OPPORTUNITIES

EZ PCB	87
--------------	----

BUYING ELECTRONIC SURPLUS

Earth Computer Technologies	52
GreenChip	52
Jaycar Electronics	49

CCD CAMERAS/ VIDEO

Circuit Specialists, Inc.	106-107
Cosmos	29
Matco, Inc.	52
PolarisUSA Video, Inc.	11
Ramsey Electronics, Inc.	12-13

CIRCUIT BOARDS

Blink Manufacturing	53
Cunard Associates	52
ExpressPCB	31
EZ PCB	87
Maxstream	26
Micromint	86
PCB Cart	43
PCB Pool	17
Pulsar, Inc.	52
R4Systems, Inc.	63
Schmart Board	52

COMPONENTS

Electronics123	64
Front Panel Express LLC	94
Jameco	37
Lemos International Co., Inc.	21
Linx Technologies	62
Maxstream	26
Micromint	86
New Sensor	51, 95
Pulsar, Inc.	52

COMPUTER

Hardware

ActiveWire, Inc.	52
COMFILE Technology	3
Earth Computer Technologies	52
EasySync Ltd.	33
Halted Specialties Co.	57
Surplus Sales of Nebraska	32

Microcontrollers / I/O Boards

Abacom Technologies	28
COMFILE Technology	3
Conitec DataSystems	81
EMAC, Inc.	63
HVW Technologies	52
microEngineering Labs	50
Micromint	86
mikroElektronika	48
MVS	28

Net Media.....	2
Parallax, Inc.	Back Cover
R4Systems, Inc.	63
Scott Edwards Electronics, Inc.	56
Trace Systems, Inc.	104
World Educational Services	32
XGameStation	52

Software

IMService	26
Pioneer Hill Software	26

DESIGN/ ENGINEERING/ REPAIR SERVICES

Blink Manufacturing	53
ExpressPCB	31
EZ PCB	87
Front Panel Express LLC	94
GME Technology	52
PCB Cart	43
PCB Pool	17
Pulsar, Inc.	52
R4Systems, Inc.	63
Trace Systems, Inc.	104

EDUCATION

Atlantic Int'l Institute, Inc.	64
Command Productions	27
EMAC, Inc.	63
Hobby Engineering	21
Schmart Board	52
Syspec, Inc.	10
XGameStation	52

EMBEDDED TOOLS

Logical Devices	36
-----------------------	----

ENCLOSURES

Integrated Ideas & Technologies, Inc.	64
--	----

EVENTS

ROBO Business 2006	65
--------------------------	----

KITS & PLANS

C & S Sales, Inc.	42
DesignNotes.com, Inc.	43
Earth Computer Technologies	52
Electronics123	64
EMAC, Inc.	63
Hobby Engineering	21
Industrial Ventures	52, 99
Information Unlimited	29
Jaycar Electronics.....	49
Plans & Kits Unlimited	104
QKITS	53
RABBIT Semiconductor	7
Ramsey Electronics, Inc.	12-13
Scott Edwards Electronics, Inc.	56
XGameStation	52

LASERS

Information Unlimited	29
-----------------------------	----

MISC./SURPLUS

All Electronics Corp.	72
Front Panel Express LLC	94
GreenChip	52
Halted Specialties Co.	57
MCM	42
Oatley Electronics	50
Plans & Kits Unlimited	104
Surplus Sales of Nebraska	32

MOTORS

Jameco	37
--------------	----

OPTICS

Anchor Optics	27
---------------------	----

PROGRAMMERS

Conitec DataSystems	81
Electronics123	64
Logical Devices	36
microEngineering Labs	50
mikroElektronika	48

PUBLICATIONS

Mouser Electronics	87
--------------------------	----

RF TRANSMITTERS/ RECEIVERS

Abacom Technologies	28
Linx Technologies	62
Matco, Inc.	52

ROBOTICS

COMFILE Technology	3
CrustCrawler	17
Hobby Engineering	21
HVW Technologies	52
IMService	26
Jameco	37
LabJack	63
Lemos International Co., Inc.	21
Lynxmotion, Inc.	87
mikroElektronika	48
Net Media	2
ROBO Business 2006	65
Robot Power	52

SATELLITE

Lemos International Co., Inc.	21
------------------------------------	----

SECURITY

Cosmos	29
Information Unlimited	29
Linx Technologies	62
Matco, Inc.	52
PolarisUSA Video, Inc.	11

TEST EQUIPMENT

C & S Sales, Inc.	42
Circuit Specialists, Inc.	106-107
Conitec DataSystems	81
DesignNotes.com, Inc.	43
EasySync Ltd.	33
Electronic Design Specialists.....	94
GME Technology	52
Jaycar Electronics.....	49
LabJack	63
Link Instruments	5
Pioneer Hill Software	26
Pico Technology Ltd. UK	28
Syspec, Inc.	10
Trace Systems, Inc.	104

TOOLS

C & S Sales, Inc.	42
GME Technology	52

WIRE, CABLE AND CONNECTORS

DesignNotes.com, Inc.	43
Jameco	37

Abacom Technologies	28
ActiveWire, Inc.	52
All Electronics Corp.	72
Anchor Optics	27
Atlantic Int'l Institute, Inc.	64
Atomic Time	43
Blink Manufacturing	53
C & S Sales, Inc.	42
Circuit Specialists, Inc.	106-107
COMFILE Technology	3
Command Productions	27
Conitec DataSystems	81
Cosmos	29
CrustCrawler	17
Cunard Associates	52
DesignNotes.com, Inc.	43
Earth Computer Technologies	52
EasySync Ltd.	33
Electronic Design Specialists.....	94
Electronics123	64
EMAC, Inc.	63
ExpressPCB	31
EZ PCB	87
Front Panel Express LLC	94
GME Technology	52
GreenChip	52
Halted Specialties Co.	57
Hobby Engineering.....	21
HVW Technologies	52
IMService	26
Industrial Ventures	52, 99
Information Unlimited	29
Integrated Ideas & Tech.	64
Jameco.....	37
Jaycar Electronics.....	49
LabJack.....	63
Lemos International Co., Inc.	21
Link Instruments	5
Linx Technologies	62
Logical Devices	36
Lynxmotion, Inc.	87
Matco, Inc.	52
Maxstream	26
MCM	42
microEngineering Labs	50
Micromint	86
mikroElektronika	48
Mouser Electronics	87
MVS	28
Net Media.....	2
New Sensor.....	51, 95
Oatley Electronics	50
Parallax, Inc.	Back Cover
PCB Cart	43
PCB Pool	17
Pioneer Hill Software	26
Pico Technology Ltd. UK.....	28
Plans & Kits Unlimited	104
PolarisUSA Video, Inc.	11
Pulsar, Inc.	52
QKITS	53
R4Systems, Inc.	63
RABBIT Semiconductor	7
Ramsey Electronics, Inc.	12-13
ROBO Business 2006.....	65
Robot Power	52
Schmart Board	52
Scott Edwards Electronics, Inc.	56
Surplus Sales of Nebraska	32
Syspec, Inc.	10
Trace Systems, Inc.	104
World Educational Services	32
XGameStation	52

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- Dual back-lit display and K type thermocouple
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Protek



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> Test Equipment > Digital Multimeters

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Details at Web Site > Test Equipment > Power Supplies



Triple Output Bench Power Supplies

with Large LCD Displays

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- Load Effect: $5 \times 10^{-4} = 2\text{mV}$
- Ripple Coefficient: $< 250\text{uV}$
- Stepped Current: 30mA +/- 1mA
- Input Voltage: 110VAC



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ESD Safe CPU Controlled SMD Hot Air Rework Station

The heater and air control system are built-in and adjusted by the simple touch of the front keypad for precise settings. Temperature range is from 100°C to 480°C / 212°F to 896°F, and the entire unit will enter a temperature drop state after 15 minutes of non-use for safety and to eliminate excessive wear.



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- Data Hold

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